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THE S. P. E. E. CALIFORNIA CONVENTION

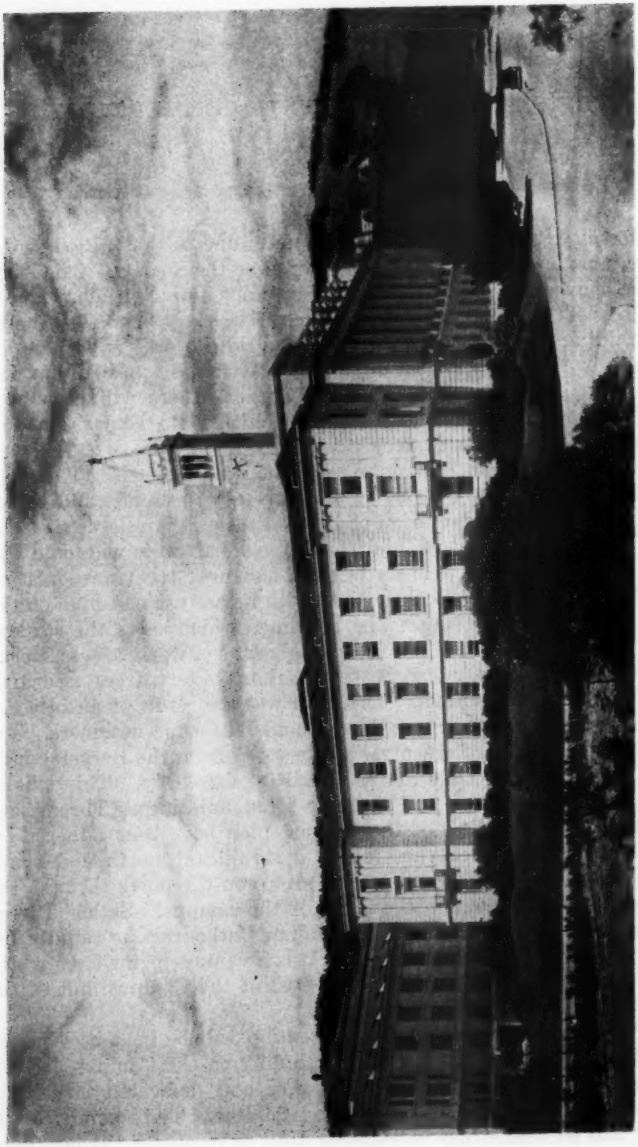
By B. M. WOODS,

Professor of Mechanical Engineering, University of California

Berkeley, California, is the place, and June 24 to 28, 1940, is the time set for the next Annual Convention of the Society. The hosts of the convention extend a hearty invitation to all members to attend this 48th annual meeting. Preparation of papers on the theme "Unfolding Obligations in Engineering Education" is well under way, as is also the preparation of physical accommodations for the meetings. Aside from the technical sessions there will be opportunities for the delegates to see the Golden Gate Exposition and other points of interest.

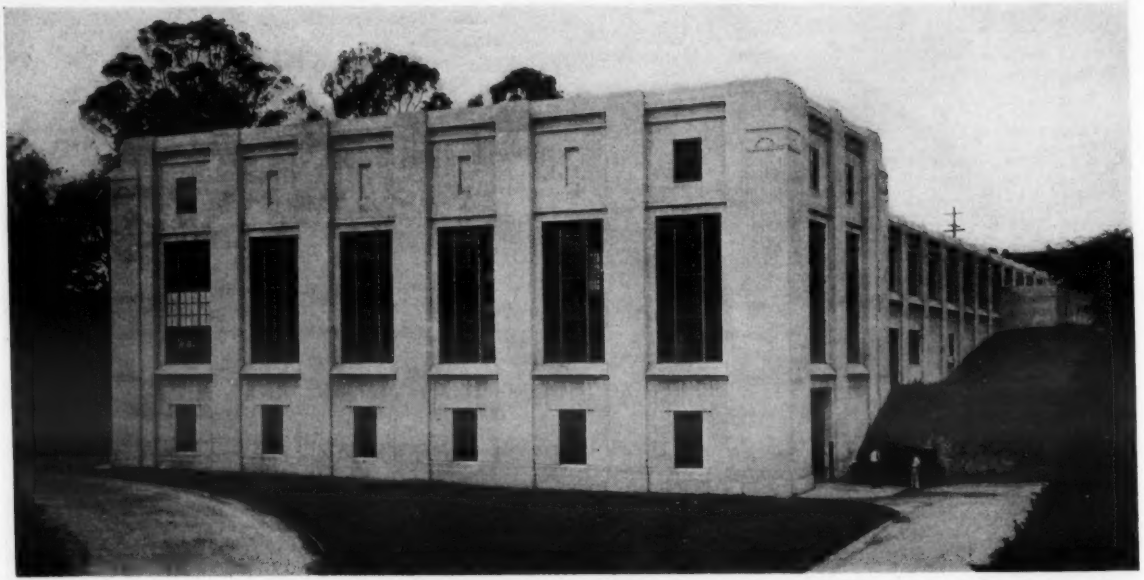
Naturally the center of interest is the campus itself. The state of California is justly proud of its University grounds and buildings, as it is of the reputation of the institution there located. The grounds occupy a plot of land roughly one-half mile wide and one mile long, which lies with its western end near the transportation and business center of Berkeley and with its eastern end high on the hills overlooking the Bay. The buildings which serve the student body of 17,000 for classroom and laboratory work are scattered among the live oaks, eucalyptus and other western trees according to a plan adopted in 1899. This plan was the result of an international competition among architects and landscape designers. Essentially it consists of a central axis erected from the Berkeley hills toward the Golden Gate across San Francisco Bay. This axis is bounded with granite- and concrete-faced buildings. Throughout the years the essentials of the original plan have been adhered to. Gradually development has led to a significant north and south axis, passing from the Engineering group on the north through the Sather Tower and out to the south of the campus. Sather Tower, modeled after the bell towers of Italian Cathedrals, is rapidly becoming the hub of the University. It is a vantage point from which to see, not merely the points of interest of the Campus, but of the entire San Francisco Bay region.

The general sessions of the convention will be held in Wheeler Auditorium, the largest classroom building on the Campus, located a short distance west of Sather Tower and dedicated largely to classes of the College of Letters and Science. The committee sessions will be held either in Wheeler Hall or in one of the buildings



WHEELER HALL, Convention Headquarters, with Sather Tower in the background.

Airplane view of the campus from the west side. Sather Tower, with its clock and observation platform stands near the center of the picture. Wheeler Hall, Convention Headquarters, is in front and just to the right of Sather Tower. To the left and behind are the buildings of the Engineering group.



Engineering Materials Laboratory, housing the large strength testing machine as well as the Civil Engineering Laboratories.

of the engineering group which lies about a hundred yards north of Sather Tower.

The Hearst Memorial Mining Building, in which is conducted a very complete Mining College, is one of the prominent buildings in the Engineering group. Near it is the Materials Testing Laboratory within which will be found the largest strength-testing machine in the West.* Other buildings in the group are the Mechanics Building with its laboratory facilities for electrical and mechanical engineering; Engineering Design with its drafting and display rooms, and Hesse Hall with its heat power laboratories. A short distance southeast of the Engineering group will be found the buildings used by the Departments of Physics and Chemistry. One of the buildings in this group houses the world-famous cyclotron, built by Dr. Ernest O. Lawrence, recent Nobel Prize winner.

Besides furnishing the state with facilities for educating its young people, the University has participated in many coöperative technical projects of value to the state and its industries. The State Department of Motor Vehicles maintains in the Mechanics Building a very extensive laboratory in which are tested headlights, signalling devices and other automobile accessories which must meet State requirements. Researches in the Materials Testing Laboratory have contributed to the success of the San Francisco Bay bridges, the Boulder Dam, the Grand Coulee Dam and other major structures of the West. Other coöperative researches carried on recently include studies in the fields of fluid metering (American Society of Mechanical Engineers); air conditioning (American Society of Heating and Ventilating Engineers); combustion (Pacific Coast Gas Association).

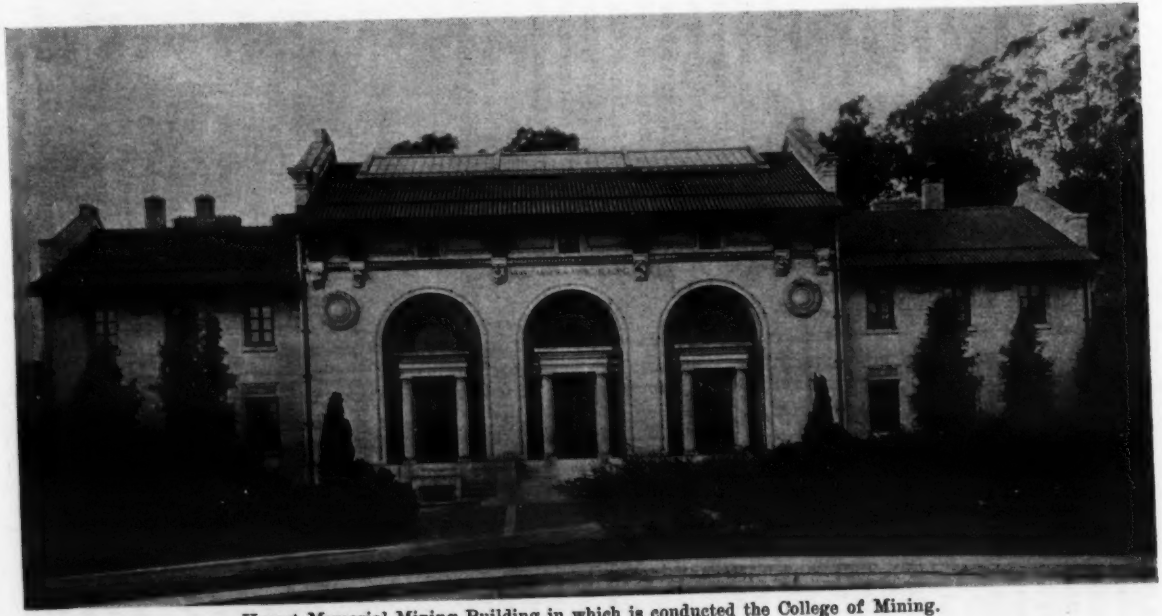
The Colleges of Mining and Engineering have grown rapidly in the last few years. The organization of engineering instruction at the University of California provides, in addition to separate colleges for students in mining and engineering, a College of Chemistry and a College of Architecture. In addition, engineering instruction is offered on the Davis Campus by the College of Agriculture in the field of Agricultural Engineering. The composite enrollment of students interested in fields of engineering, mining, chemistry and architecture now numbers about 3,216. There is a new and increasing emphasis on graduate work in appropriate fields. Facilities for this work may be inspected in the many laboratories.

Near at hand and plainly visible from the campus there are several points of interest. In the immediate vicinity of the host institution stand the famous San Francisco Bay Bridges. The San Francisco-Oakland Bay Bridge connects the metropolitan Oakland

* The Engineering Building, proper, newest in the group, houses the administration and provides library and classroom facilities.

The new Engineering Building, which houses the administration of the College of Engineering and provides library and class room facilities for the Engineering students. The older Mechanics Building appears in the right hand side of the picture.

The new Engineering Building, which houses the administration of the College of Engineering and provides library and class room facilities for the Engineering students. The older Mechanics Building appears in the right hand side of the picture.



Hearst Memorial Mining Building in which is conducted the College of Mining.

area with San Francisco over a structure about eight miles long. The Golden Gate Bridge spans the historic harbor entrance. The central span of this great structure, 4,200 feet in length, represents the maximum yet reached by engineering designers. No one, especially those concerned with engineering, can fail to marvel at these amazing structures. Their service to the area has profoundly modified the life of the people of San Francisco and the East Bay cities. Half-way across the Bay Bridge is the man-made Treasure Island, present site of the Golden Gate International Exposition and future air base. Opening its gate in May for a second season, the Exposition presents to the visitors a picture of the resources and development of the whole Pacific Basin as well as of the western United States.

San Francisco needs little introduction. Built upon steep hills, it offered transportation problems which in some instances were only solved satisfactorily with the old-fashioned cable car. Discriminating tourists for years have commented on the many restaurants in which meals according to any national or local preference can be had. Chinatown continues to be a point of interest to all visitors. San Francisco is a colorful city. Information on other points of interest will be given in an early issue of the JOURNAL.

The University of California welcomes this opportunity to entertain the members of the Society at the 48th annual convention. It is hoped that great numbers will find it an interesting, instructive and recreational part of their summer's activities.

Inquiries may be addressed to the local chairman for the meeting, Professor B. M. Woods, University of California, Berkeley; or to the Secretary of the Society.

VISUAL EDUCATION EXHIBIT

The Committee on Visual Education, which is a sub-committee of the Committee on Instructional Methods, is planning for an exhibit of visual aids at the University of California meeting. Especially desired are home-made models, films, and devices designed to teach principles and demonstrate mathematical concepts. It is requested that all who may have such material either send or bring same to Berkeley. If models are available but cannot conveniently be sent to California, it is suggested that photographs of such be sent with a brief description of the device. Photographs will be very acceptable and will be displayed.

For further information address Professor William R. Bryans, New York University, University Heights, Bronx, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

REPORT OF COMMITTEE ON AIMS AND SCOPE OF ENGINEERING CURRICULA*

The appointment of this committee was authorized at a joint meeting of the Council and institutional delegates held during the annual convention of June, 1939. The occasion for its appointment was the discussion, which had been active for some time, of the need of extending the period of undergraduate curricula to five or six years. There was active discussion also of the desirability of a preliminary period of study in schools of liberal arts before admission to the engineering school. A bill had recently been introduced in the Legislature of the State of New York intended to promote this practice by giving credit for such educational experience to those applying for professional licensure.

The committee was instructed to examine the various aspects of this matter and to present a report at an informal meeting of members of the Society to be held at Washington during November. A preliminary report was therefore prepared for discussion by those present at the meeting. Other members of the Society, engineers in practice, and educational leaders were invited to submit criticisms and suggestions, and copies of the report were sent to presidents and deans of institutions offering engineering curricula. The present report has been prepared, therefore, as a result not only of the deliberations of the committee but in the light of expressions of the views of many others.

In directing its attention to the matter of the length of the curriculum, the committee has naturally and of necessity considered the broader aspects of engineering education which bear upon the specific problem and presents its report as one dealing in general with the aims and scope of engineering curricula.

The committee has held two meetings, one of three days duration. A sub-committee has also held several meetings to edit drafts of the report prepared at general meetings of the committee. These drafts have then been circulated and re-edited. During the concluding stages of this process the committee has enlisted the cooperation of Mr. J. R. Killian, Jr., of the Massachusetts Institute of Technology.

* Copies of this report may be secured from the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

The committee comprises the following members:

J. W. Barker	H. J. Gilkey
F. L. Bishop	W. O. Hotchkiss
E. S. Burdell	E. L. Moreland
G. M. Butler	W. E. Wickenden
I. C. Crawford	H. E. Wessman
R. E. Doherty	H. P. Hammond, *Chairman*

While approving much of the material in the report, Dean Butler dissents from the view that a satisfactory professional engineering curriculum can be provided in four undergraduate years.

I

Current Problems

From its very nature, engineering education operates under changing conditions which constantly challenge its processes and test its results. Its recent history has therefore been one of continuing appraisal and adaptation to changing needs.

Continuation of this process of self-examination seems now to be called for by new conditions, trends, and attitudes that will be readily recognized:

(*a*) The thoughtful public has become aware in recent years of the technological nature of our civilization and of the part that engineers must play in the solution of many of its problems. There is therefore a widespread insistence that the technological professions should be competent to evaluate the social problems with which they deal and to recognize the social forces which they create.

(*b*) Within the engineering fraternity there is a concerted effort toward a clearer definition of professional status and function coupled with higher qualifying standards and more adequate safeguards for both the practitioner and the public. Among some engineers there is also a desire to reduce the numbers of those preparing for engineering careers.

(*c*) Others would seek, rather, to secure further recognition of the engineer's vital function, both technical and administrative, in industry and government.

(*d*) Many leaders in education are supporting a movement to make education beyond the secondary school more widely available and to postpone entry upon specialized study until a preliminary period of general study in college has been completed. Particular aspects of this movement are the establishment of many junior colleges in urban and regional centers and the setting up of "general colleges" or junior divisions within universities.

(*e*) Engineering education finds itself confronted also by the rapid and constant advance of science and by the swift changes in technology. New knowledge, new techniques, and new fields of application are pressing for adequate attention in our curricula and the limitations of time imposed by a four-year course of study make the resulting problems acute.

(*f*) This elaboration of knowledge and the resulting specialization in college faculties tend to place emphasis on particular items of knowledge at the expense of fundamental relationships. Many engineering educators are therefore seeking ways of increasing thoroughness and breadth of instruction in fundamental matters and of stimulating among students initiative, resourcefulness, and originality.

In the light of these conditions and attitudes we believe that the engineering colleges will desire at this time to examine anew their functions as institutions of higher education, to reconsider the selection and grouping of their materials of instruction, and to weigh without prejudice the duration and character of the formal training needed to prepare engineers for their careers, whether in more highly professional capacities or in other technical and administrative service of industry and government.

II

Controlling Factors

The institutions in which engineering is taught include universities of complex organization, land-grant colleges, privately endowed and publicly supported institutes of technology, colleges with associated curricula in liberal arts and in engineering, and junior colleges which offer the first two years of engineering. Despite this diversity in organization, there is among engineering colleges a basic uniformity of aims, ideals, methods, and standards of undergraduate instruction. This homogeneity is not the result of any imposed standardization; it is derived from a strong sense of solidarity among the different institutions and from the common ends they serve. In these circumstances there is ample opportunity for well-considered variations in curricula and for educational experimentation.

Within the broad realm of technology are functions which are highly diverse and exist on many levels of responsibility. Some of them are in a high degree professional, others are sub-professional or non-professional in nature; some are scarcely to be distinguished from pure research, while others verge on commerce or finance. Diversity is, in fact, one of the basic characteristics of engineering services.

While the activities of engineers have a common denominator in the engineering method, they are too numerous and varied to fall within any definition of a profession that could be legally defended and applied. These responsibilities include the entire range of technical and executive direction involved in the production of fuels and industrial materials, the planning and erection of structures, the design and fabrication of industrial products, the planning and operation of utility services, the ordering of industrial plants and processes, the sale of technical products and their adaptation to special uses, and the administration of technical enterprises, both private and public. The education of men for all these activities lies within the responsibility of the engineering college.

Since the *engineering profession* clearly cannot isolate itself from this complex of men and functions as a well-defined caste, it may be said to exist as a vaguely bounded nucleus within a much larger enveloping group which we may call the *engineering fraternity*. While progress is being made in defining the boundaries and standards of this professional nucleus and in giving it legal status through state registration, diversity of practice and fluidity of organization still remain distinguishing characteristics of engineering groups.

In the conduct of engineering education the colleges are associated with an important group of professional societies, some primarily technical and some concerned mainly with professional status. They are associated also with state licensing boards, with industrial interests, and with agencies of government concerned not only with education but also with social welfare, scientific research, the regulation of industry, and the direction of public works.

These many-sided relationships and the diverse activities of engineers have had a determining influence on engineering colleges and their programs. These institutions should not be considered as professional schools in the exclusive sense, as are the schools of law, medicine, and theology. Rather, they constitute one of the major functional branches of the national system of higher education; the technological branch as distinct from agriculture, commerce, journalism, education, and the like. For the most part engineering colleges have given their students a sound, general education distinctive in type and useful in a wide range of occupations. They have emphasized professional responsibilities and ideals more than other colleges of a general functional type, and this emphasis has contributed to the coherence of their work, but few have made preparation for strictly professional practice their predominating objective.

The varied activities and responsibilities demanded of engineers have had another important result. For many years engineering schools devoted themselves almost wholly to instruction on an undergraduate level, but in recent years a large number of them have extended their teaching and research to include the entire range of undergraduate and postgraduate activity.

Students served by engineering colleges for the most part are young men who have been drawn at a relatively early age by the appeal of applied science. Some of them have been influenced by the favorable placement of engineering graduates or by the fact that they can be prepared for self-support in four years. Many of these students are the unsifted products of the secondary schools except as early fixation of interest and the distinctive entrance requirements of some engineering schools serve as selective influences. Because of the popular appeal of the college degree and the unfortunate lack of recognition of excellent types of institutions other than the degree-granting college many students enter engineering colleges who would have better prospects of success in institutions offering a briefer and more practical type of program.

Among those who are well qualified for college, the motivation of practical interest is usually strong, but a definitely intellectual interest often needs to be awakened and nourished in college if it is to survive after graduation. The purpose to follow a career in the more highly technical aspects of engineering or to seek one in the commercial or executive ranks of industry usually remains only partly formed until graduation approaches. A substantial and increasing proportion of those who decide upon a career in technical engineering continue as advanced students, although often on a part-time basis and not infrequently through training programs offered by industry.

Guiding their students in a progressive choice of career aims is one of the major responsibilities of an engineering college. While it would be to their great advantage to divert many applicants to other types of institutions and to select their students with greater discrimination, proposals which might lead to a break in the continuity of the guidance process in the college period ought to be examined with critical care.

III

General Policy

In considering the trends and attitudes outlined in Section I and the conditions affecting the conduct of engineering education described in Section II it seems clear that the problems of the engi-

neering colleges might be simplified by restricting their function to the training of men for the higher professional levels. It must be borne in mind, however, that at present engineering colleges constitute almost the sole agency for preparing young men for technological pursuits. For the common good, therefore, technological education must be kept widely available, its admission requirements should correspond to present needs and interests of young men, and its terminal points should conform to the varied needs of industry and the public service as well as to the standards of admission to the engineering profession. Until other types of institutions are established in sufficient numbers to assume a significant part of the burden, satisfaction of these needs must continue to be the duty of the engineering colleges. Moreover, it is an obligation clearly to be recognized in the constitution of many of our institutions, including the large group of land-grant colleges which were established to diffuse scientific knowledge among the industrial classes rather than to canalize it in strictly professional channels.

In view of their broad function and their complex relationships, we consider it neither feasible nor socially desirable for the present group of engineering colleges to limit their aim to the preparation of young men for professional registration and practice. Neither do we see any reasonable means of dividing these colleges into two groups, one to include only professional schools in a strict sense and the other to comprise more general schools of industrial technology.

In addition to providing the elements of a widely useful general education the engineering colleges should specifically provide: (1) a professional discipline in the several branches of engineering, and (2) preparation for numerous executive, commercial, and service functions in technical industries and public agencies which are not strictly professional in character, although of comparable responsibility. These two fields require nearly identical foundation training with a broad scientific and social base and adequate grounding in engineering methods of analysis and application. The higher and more specialized forms of technical training are essential only in professional activity, and cannot be provided adequately in undergraduate curricula alone.

We are encouraged by recent evolutionary trends, which include a broadening of undergraduate curricula and a pronounced increase in graduate work, to believe that the ends suggested in Section I can be obtained by further changes in the selection and grouping of studies and improvements in methods of instruction, by better selective processes of admission, and by further development of graduate work where more specialized or advanced training is desirable. Furthermore, we believe that constantly chang-

ing needs can be better met within the present framework of undergraduate and postgraduate studies in the colleges and of advanced training programs provided by industry than they can through a program uniformly extended for all engineering students.

While we believe that the broad aims which have characterized engineering education should be preserved, a clearer definition of its scope seems highly desirable. Engineering education rests on a foundation of science, of humanities, and of social relationships rather than on the practical techniques of particular occupations or industries. Training in such practical techniques should require less than four years. Moreover, occupational demands which might be served by training of this type are potentially much larger than those requiring an engineering degree. Since few schools of this kind now exist above the secondary level their number should be greatly increased in order to broaden the opportunity for technical education. Greater recognition, furthermore, should be given to these institutions in order that their importance in our educational structure may be appreciated and understood. A highly desirable result of such a development would be to open new paths of success and placement to many young men of good abilities, but with practical rather than scientific interests, who now enter the engineering colleges with a resulting disadvantage to themselves and to the colleges.

Considering only those young people to whom the education given by an engineering college is well adapted, we believe that their needs cannot properly be met by a program of uniform length, although we are convinced that the course leading to the bachelor's degree conforms well to the interest and career requirements of a large proportion of these students. For many of this group graduation represents a genuine limit of time and of means available for formal education; for many it represents also a scholastic attainment satisfying their tastes and native endowments. Moreover, this level of attainment conforms well to the personnel requirements of many service functions in industry, in engineering organizations, and in government agencies. We believe the imposition of a longer college program on all engineering students through a prescribed five- or six-year course would be inconsistent with the financial resources, career needs, and abilities of many of this large group.

Preparation for the higher technical levels of engineering is unquestionably a duty of the engineering colleges. Such preparation clearly requires more than a four-year period and should extend beyond the baccalaureate degree. Provision for postgraduate education is necessary, furthermore, if adequate time is to be allowed in the undergraduate period for thorough grounding in

the basic sciences, for laying the foundations of a social philosophy, for developing powers of effective expression, and for cultivating reflective and critical habits of thought. If the undergraduate period is concentrated chiefly on these objectives, and if, at the same time, an adequate introduction is given to engineering methods of applying science to actual problems, the value of the four-year program, we believe, will be enhanced. To attain these objectives will require the transfer of some of the more advanced subject matter to the postbaccalaureate period where it may be pursued with a rigor consistent with adequate preparation for engineering specialization.

The individual's need of this advanced training is not always evident to him before graduation; frequently it cannot be discovered and defined until the individual has had some exploratory experience in practice. We believe a natural process of selection operating through individual experience in this transition from undergraduate to advanced study is a more desirable means of limiting the higher ranks of professional engineering than is the imposition of a uniformly lengthened program of studies.

We believe that the rearrangement of program and change of emphasis suggested above not only would make for thoroughness and breadth in fundamental studies, without sacrifice of the motivation which springs from youthful interest in applied science, but also would encourage greater resourcefulness, imagination, and self-development among engineering students.

We believe that there are advantages in the parallel development of the *scientific-technological* and the *humanistic-social* sequences of engineering education. When the elements of these sequences are compartmentalized and taught at different stages of the curriculum, they frequently remain unrelated and uncoördinated in the student's mind. Furthermore, a continuous development of the humanistic-social sequence prevents its complete relegation to the less mature stages of the student's career when it cannot be so effectively presented and when the student has an inadequate understanding of its importance and its bearing upon his scientific-technological studies.

We favor an integrated program of study extending through the entire undergraduate period rather than a division into separate stages. This program should be so planned, furthermore, that it may be articulated with specialized postgraduate programs.

For a minority of the students with time and money available for a period of undergraduate education extending over five years or more, we recognize that there may be advantages in a program of study in a college of liberal arts followed by work in a college of engineering. The chief advantage to be gained from this combined

program is often intangible, and resides in the experience of life and work in two diverse types of institutions quite as much as it does in any wider range of instruction.

The engineering colleges in some circumstances must coördinate their programs with those of detached junior colleges or of general colleges covering the first two years of undergraduate study in universities. This arrangement usually necessitates more than four years of study for a degree in engineering. It also involves a sacrifice in the coördination of scientific, technological, humanistic, and social studies present in well-planned four-year engineering college curricula. This observation does not apply with equal force, of course, to students who transfer from those junior colleges which duplicate the engineering curriculum of the first two years of the senior institutions.

IV

Objectives of the Proposed Policies

Certain phases of the general policy here outlined, especially those dealing directly with undergraduate curricula, require further definition and emphasis. The committee wishes to make clear that it cannot envisage at this time all the detailed measures which may be necessary to put its recommendations into effect. It is able to indicate them only in outline and without the weight of specific proposals.

First, broadening of the base of engineering education, now in process, should be continued. Its roots should extend more deeply into the social sciences and humanities as well as into the physical sciences in order to sustain a rounded educational growth which will continue into professional life. Two stems are thus implied in the undergraduate curriculum which we have designated as the scientific-technological and the humanistic-social. Each of these should be organized in an articulated sequence of subject matter and disciplines designed to lead to definite educational objectives.

The scientific-technological studies should be directed toward:

1. Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing. This implies:
   (*a*) grasp of the meaning of physical and mathematical laws, and knowledge of how they were evolved and of the limitations in their use;
   (*b*) knowledge of materials, machines, and structures.
2. Thorough understanding of the engineering method and elementary competence in its application. This requires:

(*a*) comprehension of the interacting elements in situations which are to be analyzed;

(*b*) ability to think straight in the application of fundamental principles to new problems;

(*c*) reasonable skill in making approximations, and in choosing the type of approach in the light of the accuracy required and the time available for solution—in sum, a foundation for engineering judgment;

(*d*) resourcefulness and originality in devising means to an end;

(*e*) understanding of the element of cost in engineering and the ability to deal with this factor just as competently as with technological factors.

3. Ability to select the significant results of an engineering study and to present them clearly and concisely by verbal and graphic means.
4. Stimulation of a continuing interest in further professional development.

The humanistic-social studies should be directed toward:

1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.
2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.
3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.
4. Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence upon civilization.
5. Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.
6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study.

Second, to attain the ends indicated by the foregoing general policy requires high efficiency in use of the limited time available to the student. Attainment of this efficiency means further reduction of the total content of required subject matter and concentration on fewer courses pursued simultaneously; it means minimizing purely descriptive material and repetitive tasks; it means the abandonment of effort to develop the specialized skills that are

now emphasized. It means, in brief, a process of pruning to the essentials of a sound educational content in the interest of the mastery of those essentials.

Such a process of pruning, however, does not mean the weakening but rather the strengthening of the undergraduate program as a preparation for subsequent professional development. Greater concentration of effect upon the mastery of fundamental concepts and the cultivation of intellectual powers required in the more advanced use of the engineering method would provide a more effective base for advanced scientific study, render the graduate more sensitive to the lessons of practical experience, and thus prepare him effectively for subsequent professional development.

To weaken the educational base of professional study would, of course, defeat our entire purpose. The fact must always be held in view that, while we regard the humanistic-social element as fundamental and vital to the engineering curriculum and feel that its importance must be more adequately recognized and its aims more clearly defined than they usually are at present, engineering science and method constitute, by definition, the dominant interest in the curriculum and so must be accorded the dominant portion of time. Otherwise the curriculum would no longer be within the scope of engineering education.

And finally, we reaffirm the belief that under the diverse conditions that surround and permeate engineering education no single plan as to length and nature of the curriculum applicable alike to all institutions, is either practicable or desirable. On the contrary we believe that the variety of conditions that will always pertain to science and technology require diversity rather than enforced uniformity in the educational process; and we believe especially that there should be freedom for experimentation and change in education just as there is in the world which it serves.

Summary of Conclusions and Recommendations

Engineering colleges serve diverse functions and prepare men for a wide range of technical, administrative, and executive responsibilities. Technological education should, therefore, be kept widely available, and engineering colleges must continue to serve a correspondingly wide variety of purposes. They should not limit their aim to preparing young men for professional registration and practice.

The present flexible arrangement of four-year undergraduate curricula followed by postgraduate work will better meet the needs served by engineering education than will longer undergraduate curricula of uniformly prescribed duration.

3. Engineering colleges could operate more effectively if briefer and more directly practical forms of technological education were provided by other types of institutions.

4. Advanced training for the higher technical levels of engineering should be included in the general program of engineering education but should not become its dominating aim.

5. Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies. This will require greater efficiency in the use of the student's time to be gained by pruning to the essentials of a sound educational program.

6. Some of the advanced technical subject matter now included in undergraduate curricula should be transferred to the postgraduate period where it may be pursued with a rigor consistent with preparation for engineering specialization.

7. There are advantages in the parallel development of the scientific-technological and the humanistic-social sequences of engineering curricula. The present integrated type of program extending throughout the entire undergraduate period should therefore be preserved.

8. No measures taken with respect to engineering education should limit the freedom that now exists for experimentation and change.

PHOTOELASTIC DEMONSTRATIONS AS TEACHING AIDS IN STRENGTH OF MATERIALS *

By MAX M. FROCHT

Associate Professor of Mechanics, Carnegie Institute of Technology

The object of this paper is to show how the teaching of the present contents of a first course in strength of materials by the present methods can be improved by the addition of a few photoelastic demonstrations whose effect is to clarify the subject and to stimulate the student's interest in the work he is called upon to do, as well as to encourage the pursuit of advanced studies in strength of materials and related research. The object of these demonstrations should be not to develop skill in the use of the optical methods but to impart knowledge about its essential elements and to correlate classroom and laboratory instruction.

It may be assumed that teachers of engineering generally agree:

1. That strength of materials is a fundamental subject, a key subject, so to say, in all of the basic branches of engineering and especially so in civil and mechanical engineering, and that therefore all devices that make for a clearer comprehension of the subject are to be encouraged, and
2. That the visual methods of instruction whether by slides or moving pictures have proved their value as useful pedagogical tools.

If these assumptions are sound, it would logically follow that photoelasticity, which is an experimental, visual method of stress analysis of great beauty, scope, and accuracy, can be of aid in the teaching of strength of materials. By means of photoelasticity every aspect of stress distribution in two-dimensional problems can be explored, and considerable progress is now being made into the domain of three-dimensional problems. We shall, therefore, not labor the point of the effectiveness of the visual or experimental method of instruction in general but proceed to a statement of:

1. the principles of strength of materials which are to be demonstrated,

* Presented at the Annual Meeting, S. P. E. E. (Instructional Methods), Pennsylvania State College, June 19–23, 1939.

2. the choice of the particular examples for that purpose,
3. a discussion of one major premise on which the optical science of stress analysis is based, and lastly we will indicate,
4. the application of photoelasticity to the study of the important phenomena of stress concentrations and their significance.

The engineering theory of stress analysis rests on certain simple assumptions of stress distribution and upon the laws of equilibrium. Like most engineering subjects its aims are to find useful approximations, rather than absolute scientific truths. The theory has many shortcomings and for certain problems it is inadequate. However, the author believes that this theory, in spite of all that may be said against it, will remain the guiding theory for engineers for many generations to come. The reasons for this belief are threefold: first, the theory is simple; second, it has led to useful practices; and third, it is universally used among engineers. In selecting first examples for photoelastic demonstrations it is, therefore, better pedagogy to choose examples which clarify and corroborate the basic principles of the elementary theory, rather than those which emphasize its shortcomings. When these principles have been understood and assimilated by the student in their true perspective, new material can be introduced which shows the inadequacy of the preliminary assumptions and the conclusions based upon them.

Now, what are the fundamental assumptions which are made in strength of materials, and which may require clarification and experimental support? At the risk of over-simplifying the problem the writer would set out the following topics as among the most essential ones, namely:

1. that axial loads produce uniform stress distributions in straight bars and that these stresses are given by the well known equation $s = P/a$,
2. that bending or longitudinal stresses follow a linear law which is given by the well known flexure formula, $s = My/I$,
3. that eccentric loads lead to axial stresses and bending stresses which may be combined by the principle of super-position, $s = (P)/(A) \pm (My)/(I)$,
4. that the presence of curvature in a beam tends to increase the longitudinal stresses, and
5. the theory of deflection.

Now all the above mentioned assumptions and principles can be

admirably demonstrated by means of photoelastic stress patterns not only in a qualitative but in a quantitative manner. At this point the writer would like to call attention to certain false notions and misconceptions which are current among many teachers of mechanics who though inclined to introduce elements of photoelasticity into their first courses hesitate to do so because of the erroneous belief that the necessary equipment is costly, the theory complicated and the interpretation shrouded in mystery. Such is not the case. It is, of course, true that one cannot learn to make a stress pattern of scientific accuracy over night. The theory and interpretation of available results present, however, no greater difficulties than those encountered in the study of mechanics taken as a whole. As to equipment, inexpensive polariscopes are available to-day, and one of the best ways to start on photoelastic work is to assign an interested student or a group of students to the problem of designing and building the necessary mechanical equipment which can be done for the cost of materials and labor. In introducing the elements of photoelasticity into a first course, it is perhaps best to begin by making qualitative demonstrations and supplementing these with quantitative problems based on stress patterns which can be found in published works such as books or articles.

Illustrations.—Fig. 1 shows the simplest stress pattern of a bar in pure tension which we suggest for the first demonstration. At the start it is, perhaps, advisable to cover up the fillets and to focus the attention of the class only on the shank where the stresses are uniform. This stress pattern can be used to demonstrate effectively three basic photoelastic concepts:

1. fringe or color order depending on whether the light source is monochromatic or not,
2. fringe or color value,
3. the stress optic law, *i.e.*

$$(p - q) = 2\ n\ F \quad (a)$$

or (1)

$$v_{max.} = n\ F \quad (b)$$

in which p and q denote principal stresses and n, F denote fringe order and fringe value respectively, and $v_{max.}$ denotes the maximum shear stress.

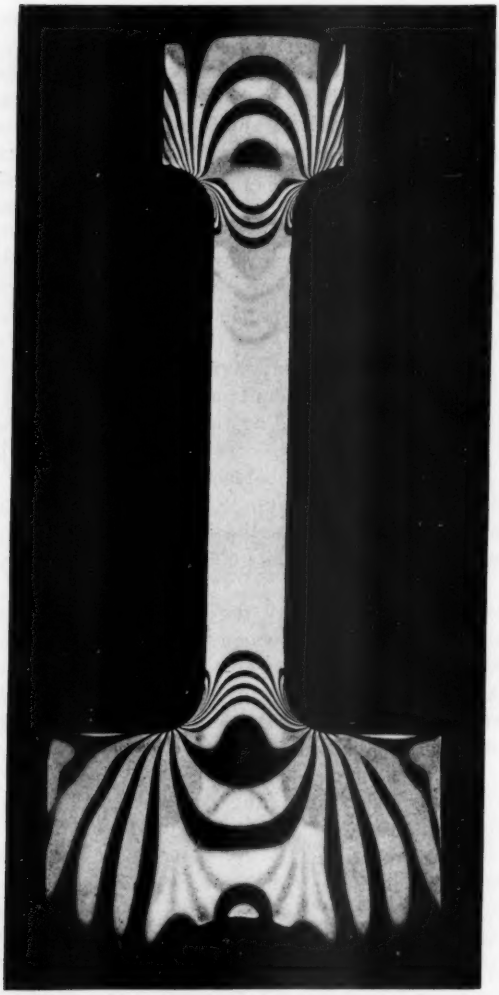


FIG. 1. Photoelastic stress pattern of a bar in pure tension. Axial load = 186.7 lbs.; width of heads = 1.118 in. and 0.517 in.; width of shank = 0.232 in.; radius of fillets = 0.125 in.; thickness = 0.241 in.; shear fringe value of model = 178 psi.

Figure 2 shows the next simplest stress pattern, namely, that of a beam in pure bending which is suitable for the second demonstration. Again it may be advisable to show only the central parts.

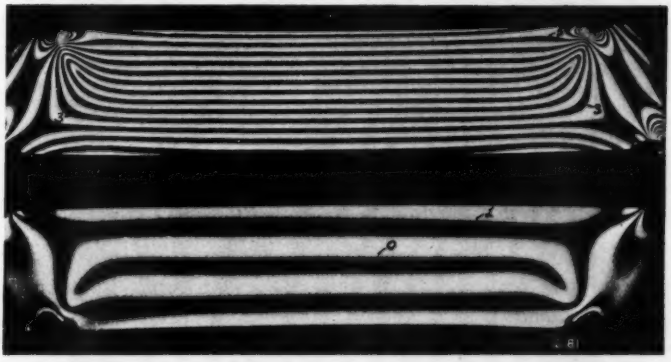


FIG. 2. Photoelastic stress patterns of beams in pure bending showing relative optical sensitivity of bakelite and celluloid. Upper beam bakelite, lower beam celluloid. Note that the fringes are parallel and equidistant substantiating the linear law of distribution of bending stresses.

This stress pattern shows the existence of a neutral axis as a reality and not as a mathematical abstraction. It corroborates also the law of linear distribution of longitudinal stresses. Thus in pure bending q is assumed to vanish so that the remaining principal stress p, which represents the longitudinal or bending stress, is by eq. (1) given by

$$p = C\ n,$$

where the constant $C = 2\ F$. It follows that the fringes must be parallel and equidistant as shown in Fig. 2.

Figure 3 shows a stress pattern of a rectangular block subjected to a pair of eccentric loads and Fig. 4 shows comparative curves for the normal stresses across the section of symmetry. Inspection of these curves shows very good agreement between the photoelastic and calculated results. The curves thus substantiate the principle of superposition which is expressed by the equation

$$s = \frac{P}{A} \pm \frac{Mc}{I}$$

and which was used in the calculation of the stresses.

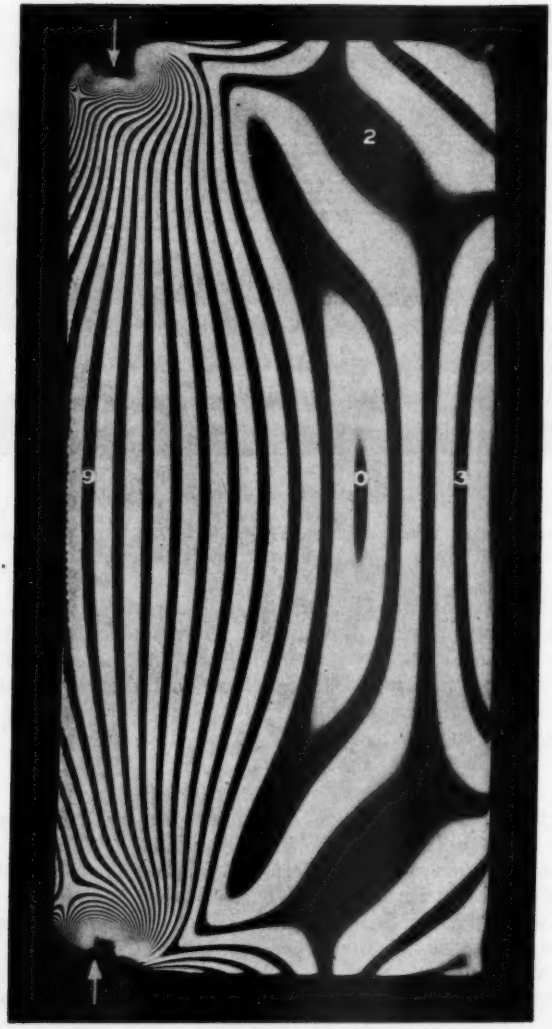


FIG. 3. Photoelastic stress pattern of a rectangular bar eccentrically loaded. Shear fringe value of model = 254 psi.

Figure 5 shows a stress pattern of a portable crane and Fig. 6 gives the comparative curves of photoelastic and calculated results for the central horizontal section. These curves corroborate further the principle of superposition. At the same time it furnishes a rather practical illustration of the detrimental effect of curvature which is illustrated more clearly in the next stress pattern.

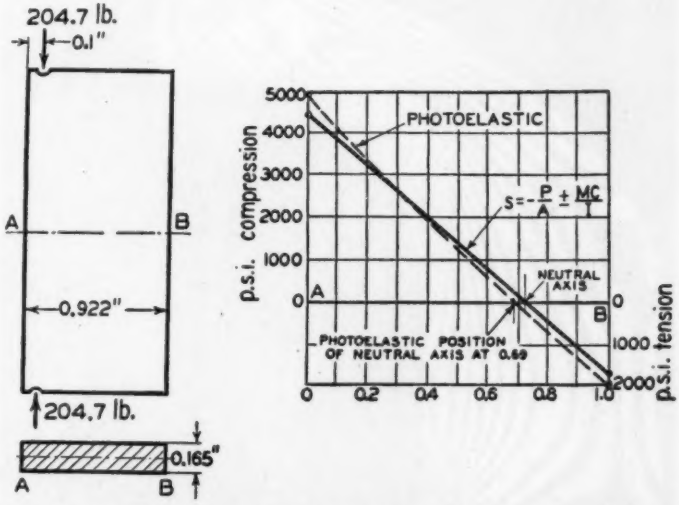


FIG. 4. Loads and dimensions, and comparative curves of photoelastic and theoretical stresses across the transverse section of symmetry for the bar the stress pattern of which is shown in Fig. 3.

Figure 7 shows two beams having identically the same transverse sections. One of these is straight; the other is curved. As shown in Fig. 7 the arrangement of the loads is such that the central sections are subjected to the same bending moments and zero shear. Inspection of the corresponding stress pattern in Figure 8 shows clearly that the curved beam is stressed higher than the straight beam. It is left as an exercise to the student to calculate the boundary stresses in the curved beam and to compare it with the photoelastic results.

Figure 9 shows a stress pattern of a restrained beam having a region of pure bending in the center. The corresponding comparative curves of the boundary stresses are shown in Fig. 10. The excellent agreement between the two sets of results corroborates our

theory of deflection, for the calculated results were obtained on the assumption that the deviation at one end from a tangent at the other is zero. It will be observed that the agreement between the curves of Fig. 10 is somewhat better for the lower boundary than

FIG. 5. Stress pattern of a portable crane. Shear fringe value = 163 psi.

for the upper boundary. This is due to the greater degree of restraint which exists at the lower boundary than at the upper boundary.

Influence of Material.—The optical method rests on the premise that, except in cases of little practical importance, the stress distribution is independent of the material. The theoretical justifi-

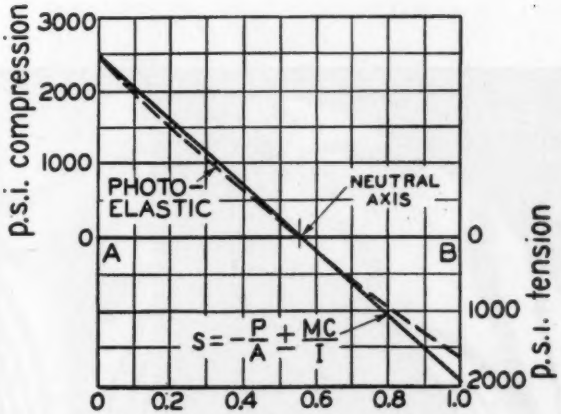


FIG. 6. Comparative curves of photoelastic and theoretical stresses across the central horizontal section for the portable crane the stress pattern of which is shown in Fig. 5.

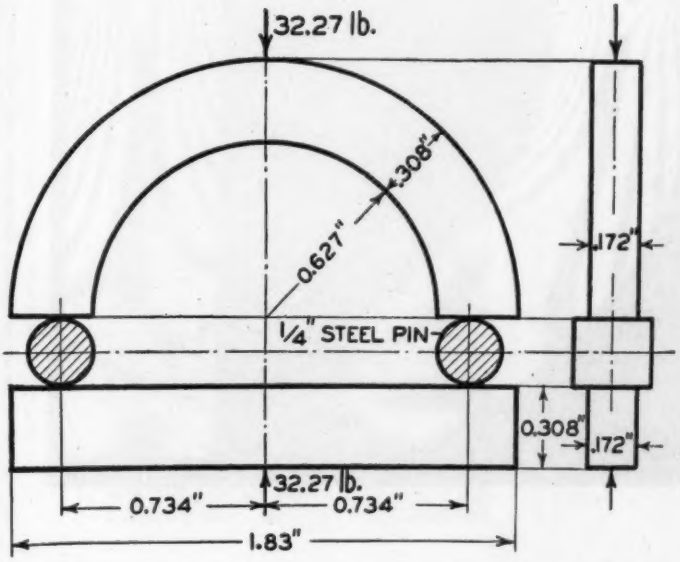


FIG. 7. Dimensions and loads for the stress patterns shown in Fig. 8.

FIG. 8. Photoelastic stress pattern showing effect of curvature on boundary stresses for a straight and a curved beam of similar dimensions and with equal applied bending moments as shown in Fig. 7. Maximum tensile stress in curved beam is 9 fringes or 4500 psi while in the straight beam it is 8¼ fringes or 4060 psi.

FIG. 8. Photoelastic stress pattern showing effect of curvature on boundary stresses for a straight and a curved beam of similar dimensions and with equal applied bending moments as shown in Fig. 7. Maximum tensile stress in curved beam is 9 fringes or 4500 psi while in the straight beam it is 8⅛ fringes or 4060 psi.

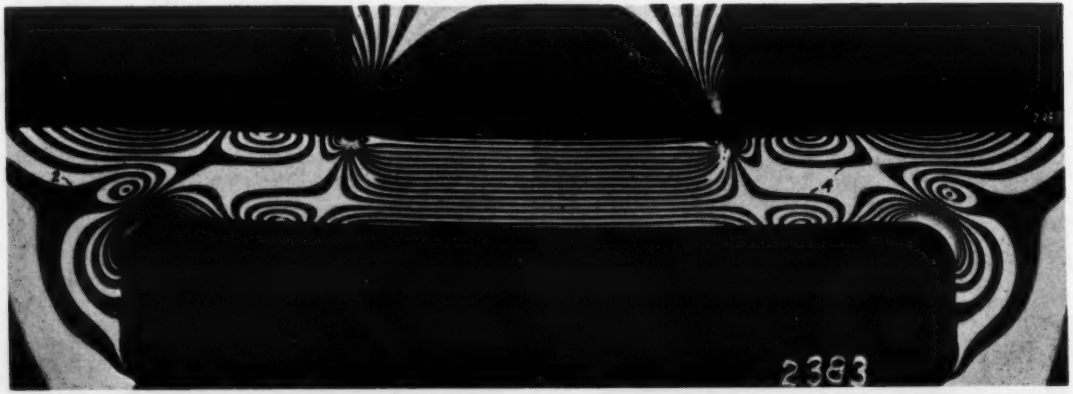


FIG. 9. Stress pattern of a restrained beam loaded by two equal loads of 23.78 lbs. each placed symmetrically about beam center. Length of beam = 1.713 in.; depth = 0.186 in.; thickness = 0.172 in.; distance of loads from center = 0.377 in.; fringe value = 500 psi (tension). Note region of pure bending in central portion of beam.

cation for this assumption is found in the equation of continuity,

$$\frac{\partial^4\phi}{\partial x^4} + 2\frac{\partial^4\phi}{\partial x^2\partial y^2} + \frac{\partial^4\phi}{\partial y^4} = 0, \tag{2}$$

in which ϕ denotes the Airy stress function.* This equation does not contain the elastic constants of the material such as the modu-

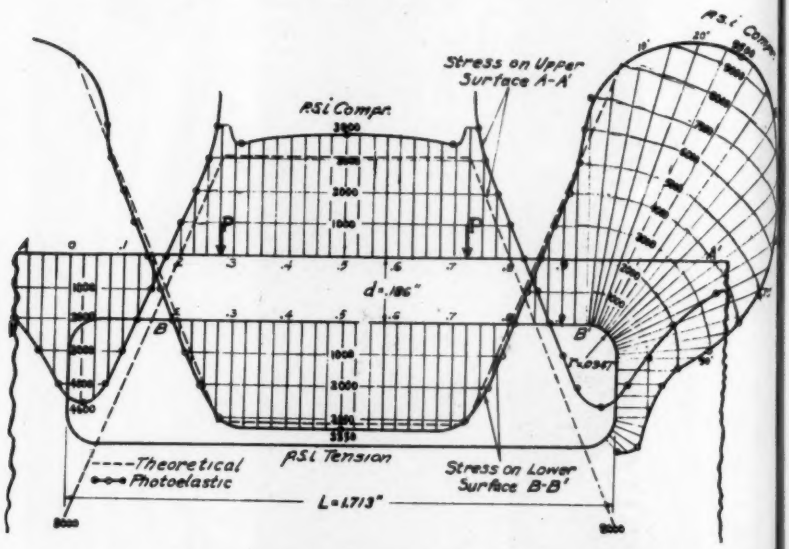


FIG. 10. Comparison of photoelastic boundary stress distribution with theoretical for the restrained beam shown in Fig. 9. Applied loads = 23.78 lbs. each, beam thickness = 0.172 in.; fringe value = 500 psi (tension).

lus of elasticity or Poisson's ratio, and it therefore follows that the stress distribution is independent of the material. Experimental evidence now exists which convincingly and conclusively shows that this theoretical deduction is true.

The Aluminum Company of America has recently investigated the factors of stress concentrations for the case of a single pin or rivet in a bar of finite width. The investigation was carried out by means of strain gauges on oversize aluminum plates of approximately five feet in width and pins 8 inches in diameter. The same

* See S. Timoshenko, "Theory of Elasticity," McGraw-Hill Book Company, New York, 1934, Chapter 2.

FIG. 11. Isopachic stress pattern from a stainless steel ring subjected to concentrated diametral loads. Dimensions of model: inner diameter = 0.375 in.; outer diameter = 0.751 in.; thickness = 0.243 in.

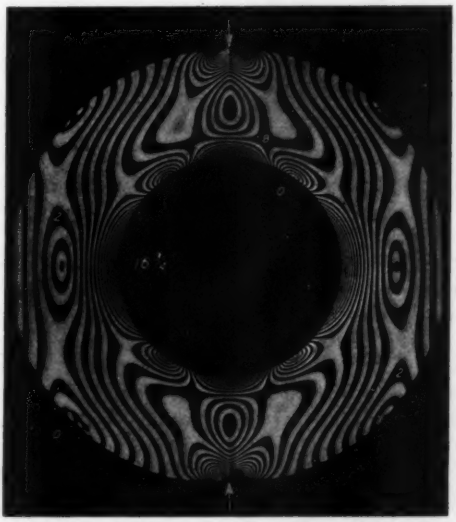


FIG. 12. Photoelastic stress pattern from a bakelite ring under concentrated diametral loads of 202.6 lbs. Dimensions: Inner diameter = 0.766 in.; outer diameter = 1.532 in.; thickness = 0.1795 in.; model fringe value = 500 ψ in tension or compression.

problem was independently studied by the writer, in the photoelastic laboratory of the Carnegie Institute of Technology, by means of small bakelite models and the photoelastic method. The two sets of results show an extraordinary degree of agreement and are now embodied in a joint paper.* This work contributes material evidence in support of the theory that the stress distribution is independent of the material.

The results from another, even more general, investigation is shown in Figs. 11, 12, and 13. Fig. 11 shows a stress pattern of a

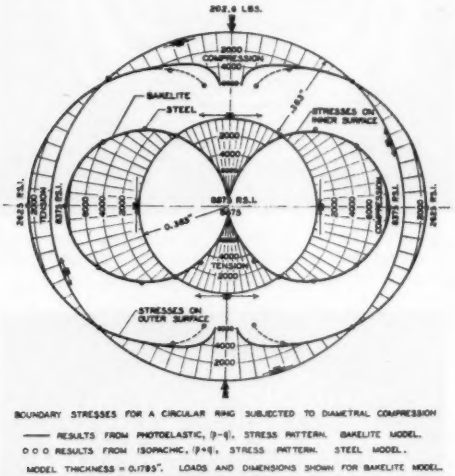


FIG. 13. Comparative curves of boundary stresses from the photoelastic and isopachic stress patterns of Figs. 11 and 12.

steel ring of 0.75 inches outside diameter and 0.375 inches inside under the action of two compressive diametral loads. The surface of the steel model was polished to an optical flat and a piece of plate glass, or 45° prism, placed over it. It is clear that under the action of the loads the initially flat surface of the steel specimen became distorted. In a two-dimensional stress system the distortions, or, more specifically, the lateral deformations δ are given by the expression

$$\delta = -\frac{\mu l}{E}(p+q) \tag{3}$$

* See M. M. Frocht and H. N. Hill, "Stress Concentration Factors Around a Central Circular Hole in a Plate Loaded Through a Pin in the Hole," presented at the Sixtieth Annual Meeting of the A. S. M. E. at Philadelphia, Pa., Dec. 4–8, 1939 and to be published soon in the *Journal of Applied Mechanics*.

with the conventional notation. It follows from this equation that $(p + q)$ is constant where δ is constant. Suppose now that the datum plane is kept fixed relative to the inherent plane of symmetry of the model during and after the application of the loads. If a beam of monochromatic light be sent through the glass datum plane, it will upon reflection from the model carry with it a stress pattern of the interference fringes, similar to the pattern of the well known Newton's rings. The interference fringes so obtained represent contours of loci of equal $(p + q)$. These contours are known as isopachic curves. Fig. 11 shows the isopachic stress pattern for the steel ring mentioned above. Now on the free boundaries there exists only one principal stress, the tangential stress. Furthermore, the free boundary stresses can be determined either from the photoelastic stress pattern shown in Fig. 12 or from the isopachic pattern in Fig. 13. A comparison of the two sets of boundary stresses will then reveal the influence of the material on the stress distribution. Fig. 13 shows such comparative curves. It should be noted that the full curves represent the results from the bakelite model and that the open circles represent the results from the steel model, and that the full curves were not drawn through the open circles. Inspection of Fig. 13 shows a most remarkable agreement, and in conjunction with the theoretical conclusion it provides irrefutable evidence that the stress distribution is independent of the material.*

This point should in our judgment be emphasized when introducing students to elements of photoelasticity.

Conclusion.—The five examples shown in Figs. 1, 3, 5, 8 and 9 † illustrate, clarify and corroborate the essential assumptions and principles in the elementary theory of strength of materials. All these experiments can be performed in a few hours and they will add immeasurably toward a clearer understanding of stress analysis. In addition, they will introduce the student to a powerful method of stress analysis which will throw light on the important phenomenon of stress concentration. Toward the end of the course attention can be directed to the effect of fillets, holes and notches as sources of stress concentration as shown in Figs. 1 and 7. The notion of a factor of stress concentration can then be introduced,

* For a detailed description of the method involved in getting the isopachic stress pattern, as well as an analysis of the results, see author's paper, "On the Optical Determination of Isopachic Stress Patterns," Proceedings of the Fifth International Congress for Applied Mechanics, held at Cambridge, Mass., Sept., 1939, published by John Wiley and Sons Co., or "Isopachic Stress Patterns," *Journal of Applied Physics*, April, 1939.

† Figures 2 to 10 inclusive are from "Strength of Materials," by N. C. Riggs and M. M. Frocht, Ronald Press Company, Publishers.

and the student can be familiarized with its application to the design of shafts subjected to fatigue. Curves of factors of stress concentration are now available ‡ and the student should be taught to use these data as he does any set of fundamental tables. The effect of stress concentrations on the endurance limit should be mentioned.

‡ See M. M. Frocht, "Photoelastic Studies in Stress Concentrations," *Mechanical Engineering*, 1936; also "Factors of Stress Concentration Photoelastically Determined," *Journal of Applied Mechanics*, June, 1935, or "Strength of Materials," by N. C. Riggs and M. M. Frocht, Chapter 13.

THE CORRELATION OF LABORATORY WORK IN STRENGTH OF MATERIALS WITH THE CLASS ROOM COURSE *

By G. P. BOOMSLITER

Professor of Mechanics, West Virginia University

Of all the tasks concerned with education, the easiest is teaching a student who wants to learn. What he wants to learn is something which he has already tasted and found to his liking.

The above quotation is taken from an article by Professor Hatcher of McGill University, published in the current Wiley Bulletin. To it might be added that we all like to do the things that we can succeed in doing—that give a sense of accomplishment. To succeed in an intellectual task we must understand what we are trying to do. Thus, the task of the successful teacher is first to instill a liking for a subject and to do this he must make the fundamental principles understandable. The laboratory work in mechanics of materials in conjunction with a classroom course makes for an understanding of the principles discussed in the classroom.

The movement of the hand of an Ames dial showing proportionality between load and elongation or load and deflection conveys a picture of Hooke's Law no amount of verbal illustration can approach. A plane section before bending can be shown to be a plane section after bending by making a few laboratory measurements. A tiny drilled hole in a torsion specimen through which the light shines even after many twists conveys the idea that a diameter remains a diameter no matter how much the rod is twisted.

Then, too, a beam in the laboratory is more than a sketch. It becomes real. The reasonableness of those confusing column formulas becomes apparent when long columns buckle under less load than short ones. And a buckle is really a buckle, not something to hold two ends of a belt together.

So, understanding is developed by laboratory work, understanding of text book phrases, of common structural elements.

I like to speak of the "feel" of materials, that the student gets

* Presented at the 47th Annual Meeting, S. P. E. E. (Instructional Methods), Pennsylvania State College, June 19–23, 1939.

in the laboratory, the "feel" of elasticity or strain. Professor Gilkey speaks of this as "materials horse sense."

And the "taste" that Professor Hatcher speaks of is there. The crowd at an engineering show stands breathless while a powerful machine breaks a sturdy specimen. If the layman is interested, how much more is the student who realizes the significance of what is occurring.

Out of my file I drew a fading blue print "Report of Committee No. 13 of this Society on Mechanics and Hydraulics on the topic 'Main Objectives in Teaching These Subjects.'" It is not dated but is not less than twenty-five years old. I quote from it:

> Mechanics is an experimental science; experimental work should accompany each course under consideration. A blind person cannot understand the theory of painting because he cannot experience the sensation of color. Similarly a student cannot comprehend mechanics unless he can experiment, because only through experiment does he obtain the fundamental concepts upon which the subject is based?
>
> The student needs experiments to illustrate in a concrete way some of the important derived facts that are developed in theory to show their degree of accuracy and to point out their limitations. . . . Such experiments should be so correlated with class instruction that these concepts and illustrations will be given to the student by the laboratory work at appropriate stages in the development of theory in the class room.

To my mind, the above quotation ably states the main objective for a laboratory course in materials. There are many others; training in observation, in compiling and analyzing data, the introduction to specifications and the laboratory methods of checking them and selecting materials, but they are secondary; useful and important by-products of the main purpose.

In planning the course schedule, serious thought should be given to the correlation referred to above. Perfect correlation is difficult. Lack of facilities and of man power unfortunately makes it necessary to do no more than approach the ideal of running tests which are coincident with the study of theory. Simple classroom demonstrations will help and reference can be made to experiments which are to be performed later in the laboratory and the reference can again be made in the laboratory to the theory which has been discussed in the classroom. But the lag should be as short as conditions will permit.

As to instruction, the ideal is to have the same men teach theory and testing to the same students. This can be done in the smaller schools but is difficult when classes are large, when the group of instructors will also be large. Next best is to have the students divided among instructors who are teaching both theory and laboratory classes. With enthusiastic teachers this will be nearly as good.

Much is lost, however, when one group teaches in the laboratory

and another in the classroom, for the laboratory man is very likely to have a different point of view from the classroom instructor. He may become obsessed with the value of the by-products. Specification testing may be his obsession, or elaborate report writing or even the mechanics of testing, and the main objective may be lost or obscured.

The situation is even more complicated when the two courses are taught in separate departments. Rare indeed is coöperation so close that one department will defer to another in carrying on its work. Unless great care is observed the viewpoint of the department under which the laboratory work is undertaken will take precedence over that of the instructional group.

In 1937 Gilkey and Lightburn * reported the disposition of mechanics courses in 133 engineering schools. In 18 of these or about 14 per cent, material testing was not given in the same department as was the instruction in properties of materials.

The engineering curriculum is crowded and every course should be given close scrutiny to determine whether or not it can be omitted. As an aid to the establishment of fundamental conceptions the materials testing laboratory is a very necessary course. If other objectives can be attained at the same time, and I am sure that they can, so much the better. However, it may be questionable to many whether this course is necessary except for special groups, when the main objective is not realized. Laboratory work is expensive, nearly three times as expensive as classroom instruction and its effectiveness is being carefully scrutinized to determine whether it is worth the cost.

Obviously many will not agree with me as to the principal objective of the materials testing laboratory. Peck † gives a list of these objectives as obtained from a questionnaire sent to 23 institutions. In the order of their frequency they were (1) first hand knowledge of the physical properties of materials; (2) acquaintance with standard tests; (3) drill in report writing; (4) illustrations of the laws of mechanics; (5) laboratory and testing technique; (6) training in observation, neatness, accuracy, patience, etc.; (7) interpretation of test data. A few included (8) a knowledge of standard specifications, and (9) knowledge of manufacturing processes.

In a report before the Division of Mechanics at the Purdue Convention the speaker ‡ presented a table showing that in 16 institutions materials testing was given combined with materials of engineering rather than the mechanics of materials and in 43

* *S. P. E. E. Journal*, Vol. 28, No. 4, p. 258.

† "The Functioning of the Laboratory in Engineering Education," by John Sanford Peck, N. Y., 1936.

‡ S. P. E. E. JOURNAL, Vol. XXII, No. 2, Oct., 1931, p. 127.

institutions it was given as a separate course, most of them, but by no means all, in conjunction with mechanics of materials.

Undoubtedly, a good course in mechanics of materials can be given without a simultaneous course in laboratory; undoubtedly an instructor, by means of personally conducted experiments, can convey the fundamental conceptions of stress and elasticity to a class; undoubtedly a combined course in materials of construction and laboratory has some peculiar advantages over classroom work alone; but most teachers of mechanics feel that the impact of ideas personally developed in a laboratory experiment plus the repetition which such impact gives of classroom principles is a powerful aid in the teaching of mechanics of materials and the course when so used is more valuable than when used in any other connection.

Although there is some variation as to types of tests and laboratory methods most schools using the laboratory as an adjunct of the classroom follow rather similar procedure. The laboratory experiments are printed with detailed instructions as to laboratory technique and methods of drawing curves. Questions often follow the instructions for each experiment.

Lately there have been developed several laboratory schedules for special purposes. Gilkey * has suggested a technique for linking the testing of materials with the study of specifications. Everett † has combined lectures, lecture-demonstrations and student tests in conjunction with the theoretical course in strength of materials in which he acquaints the student with such matters as the crystalline structure of metals, plasticity, fatigue, hysteresis, the effect of high temperatures on the properties of metals, photoelasticity and indeterminate structures.

Peck,‡ in a study conducted at the College of the City of New York, selected the materials testing laboratory in connection with a course in the materials of construction for some interesting experiments for determining the value of all laboratory instruction and for improving it as an instrument of education. He proceeded on the assumption that the laboratory should be an important factor in "awakening and directing thought" and developed a series of experiments which should call into action the five states of thinking in Dewey's "unit of thinking." These include (*a*) an awareness of a perplexity or problem; (*b*) its statement or analysis as a definite problem to be solved; (*c*) the use of a chain of suggestions to initiate and guide observations and other operations in the collection of salient facts; (*d*) the development of a logical hypothesis which will solve the problem, and, (*e*) the testing of the

* S. P. E. E. JOURNAL, Vol. XIX, No. 9, May, 1929, p. 902.

† S. P. E. E. JOURNAL, Vol. XXIII, No. 7, March, 1933, p. 504.

‡ "The Functioning of the Laboratory in Engineering Education," by John Sanford Peck, N. Y., 1936.

hypothesis. Of course this process was to have as its objective the attainment of an understanding of the physical properties of materials and of the ability to put this knowledge to use. His students, by means of library references, planned their own experiments and then performed them without the use of formal instructions. The results of this experiment when compared with the attainments of a control group using standard methods of instruction were that the new method while inferior to the standard method as far as understanding the physical properties of materials was concerned was superior in the development of the ability to solve new problems and in the promotion of interest.

A second experiment was then tried in which a definite set of results was required but the students again planned their own experiments. These results were then discussed in the classroom. The results according to the tests were equal to those obtained in the control group so far as knowledge of properties of materials and manufacturing processes were concerned but superior in other respects, for example, in developing attitudes and interests.

The results of the study convinced the author that there are better ways to teach in the materials testing laboratory than those which are now in use—better, at least, when the laboratory is considered as a device in the complete educational process.

Certain conditions should be observed before a procedure similar to Peck's is adopted.

(1) Peck attributes a lack of greater success partly to the fact that his students were bright, and therefore young and immature. However, the course was given in a course of materials of construction *after* mechanics of materials was studied, and his results show *even then* a lack of knowledge of the fundamental principles of mechanics.

(2) The method was expensive. In the second experiment, three men were required to teach four sections with a total of 56 students.

(3) The students in the mechanics of materials are younger and less mature than those in a succeeding course such as materials of construction.

(4) Peck admits of the possibility that for certain personalities this type of laboratory experience might even interfere with learning.

This reminds me of an experience which I had some twenty years ago.

Professor C. C. More * had initiated a plan for teaching mechanics at the University of Washington which has an underlying philosophy somewhat similar to that used by Peck in the materials

* ENGINEERING EDUCATION, Vol. VII, No. 9, May, 1917, p. 518.

laboratory. In other words the student was presented with an engineering situation and had to dig out his solution. I believe this plan is still used successfully there. However, I had a transfer student in one of my classes who had come from Washington. I asked him how he had liked the mechanics course there. His answer was, "That's why I'm here."

Dr. Wickenden,* in his final report on the Investigation of Engineering Education indicates that in Europe educational methods of the type experimented with by Peck and More are the rule. He, however, points to the careful selection of students over there as contrasted with the universality of college education here.

He states that American methods tacitly imply a distinction between the "student" who assimilates the recorded experiences of others and obtains conceptions which aid him in assimilating knowledge in symbolic forms, and the "learner" who must rely on his own experiences and who if not of the reflective type may simply develop habits based on these experiences. Our average student does not thrive on independent study and few even after graduation are "book-minded." Dr. Wickenden advocates such courses for the later years of the course or, better, for "honors courses." The last, however, are only possible in schools which are large enough and wealthy enough to develop and maintain such courses.

Most engineering schools are state supported and must depend upon the products of the high schools for their students. Their entrance requirements cannot be so high as to result in too rigidly excluding the prospective students who come to them. Most know that a depression has been prevalent in recent years and must exercise rigid economy and cannot afford the expense of extra instructors for special "honors" courses.

The student body contains a large proportion of "learners" and so methods must be employed which will be of service to the majority. Experience shows that the present set-up of classroom work and laboratory work given simultaneously works well when properly administered and has characteristics which are valuable to both the "student" and the "learner."

No doubt a good teacher can do a good job in materials under any set-up, but I believe that those who have had experience under both arrangements will agree that a better understanding of the laws of mechanics of materials will be obtained and greater capacity developed to use these laws, when the two courses can be given simultaneously under the same department and with the same instructor.

* "Report of the Investigation of Engineering Education," Vol. II, p. 1040, et seq.

IMPARTING KNOWLEDGE vs. DEVELOPING SKILLS IN TEACHING MECHANICS OF MATERIALS

By WM. L. DeBAUFRE

Chairman, Dept. of Engineering Mechanics, University of Nebraska

The above title was selected by Professor White of Northeastern University as a result of a comment upon his questionnaire regarding the teaching load in handling strength of materials. His questionnaire concerned an Operating Plan of teaching this subject by lecturing to a group of 60 students during three 50-minute periods a week and then dividing them into three sections during an additional 50-minute period for discussion and review. When this questionnaire was received at Nebraska, we decided to answer the questions as well as we could without experience in handling the subject in this particular manner. We then qualified our answers by the statement:

> Although replies have been based on handling this course in strength of materials as described under the Operating Plan, we do not favor lecturing to large groups of students in this course. We regard the main objective of the course to be the development of skill in applying the principles of the subject to engineering problems rather than the imparting of information. While the lecture method may be satisfactory for imparting information, it is not considered satisfactory for developing skill. We therefore divide our students into groups of twenty or less for four recitations per week in mechanics of materials. By so doing, we believe that we are able to insure more thorough study of the subject from day to day by the individual students and to give more help to each individual student to acquire the desired skill in applying the subject to practical problems.

Under the selected title, we will amplify the preceding statement by giving our reasons for preferring our method of teaching mechanics of materials to the Operating Plan of Prof. White. We have been fortunate in having teachers with extended practical as well as teaching experience in mechanics of materials. Thus, one section each semester is handled by Prof. C. M. Duff who also serves as materials and testing engineer for the State Department of Roads and Irrigation with testing laboratories in the Department of Engineering Mechanics at the University. The other two or three sections each semester are handled by Prof. J. P. Colbert and Prof. E. A. Grone. The following comments are based largely upon the observations of these three teachers.

We believe that the greatest value of mechanics of materials to the practical engineer lies in his ability to apply its principles to the solution of practical problems concerning engineering structures and machines. Engineering structures and machines are built for various purposes in the different branches of engineering work and the financial loss may be large if guaranteed conditions are not met by reason of some error in thermodynamics, or in electrical or chemical theory. But if the structure or machine fails by reason of insufficient strength due to an error in mechanics of materials, the loss of life and of property may be disastrous. This is the justification for requiring skill in structural design for registration as a professional engineer in any branch of engineering. In teaching this fundamental subject to all engineering students, we therefore believe that no effort should be spared to develop the skill of each individual student to solve practical problems.

We believe that mental development is produced in the same way as muscular development, namely, by properly directed efforts of the individuals concerned. Passively watching a football game does not develop the muscles of the spectators no matter how strenuous the muscular efforts of the players upon the field. Students may be exposed to a lecture without any mental development no matter how strenuous the mental and even muscular efforts of the lecturer.

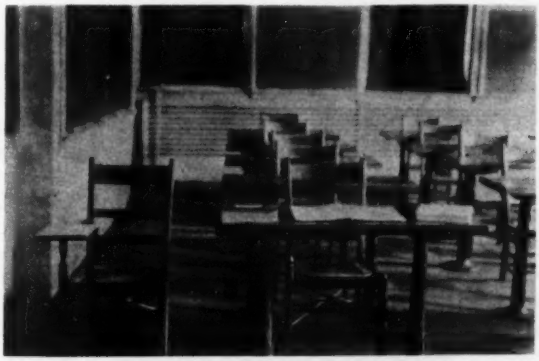
We believe that learning is an individual matter rather than a group affair. What any student learns depends upon his individual capability and particularly upon the effort he individually makes in studying a subject. The degree of mastery of any subject will vary from student to student. There is a low level of minimum achievement required of all students; but if each student develops in accordance with his capability, there will be varying heights of high attainment.

We believe that the best teacher of mechanics of materials is the one who induces individual students to put forth their best efforts to develop their skills in solving practical problems. These efforts should, of course, be directed in an effective way. The most successful teacher is not necessarily the one who works his students the hardest. However, it is the effort of the individual student rather than the effort of the teacher which determines how much the student learns.

The teaching of mechanics of materials might, of course, be conducted in accordance with these beliefs, whether the classes are organized for recitations with small numbers or for lectures with a large group of students. With a small number of students, however, the individual student can have much more intimate contact

with his teacher than if he were one of a large group. The more intimate contact in the classroom encourages the student to call upon the instructor for help outside the class room. A good teacher can therefore have a greater personal influence upon each student, not only in helping him to master a technical subject but also in other ways.

In a small class, the teacher can become better acquainted with every student than if the group were large. The strong and the weak points of every student are brought more forcibly to the notice

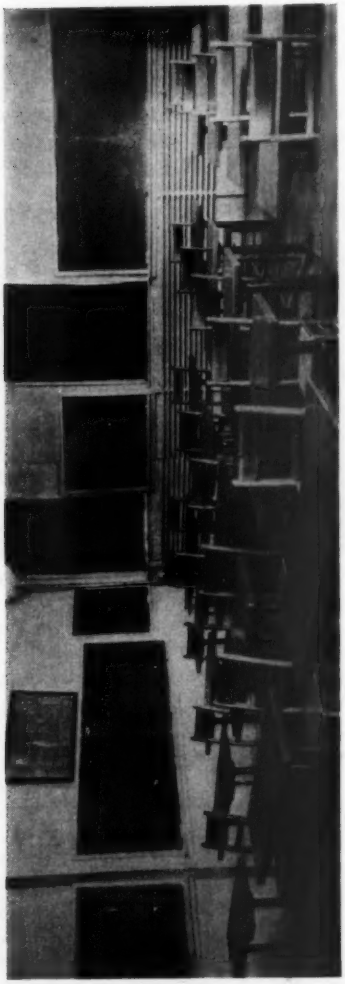


COMPARISON OF TABLET ARM CHAIR WITH TABLE FOR PROBLEM WORK IN ENGINEERING MECHANICS

of the teacher. The small number can be handled much less formally than the large group. Small size classes do not insure good teaching, but they do make better teaching possible.

By limiting the number of students to twenty in any one section, it is possible to have a classroom of reasonable size with sufficient blackboard space to accommodate all twenty students at one time. By assigning a problem to each student, the teacher can see how every student is doing by glancing around at the blackboards. The teacher can then give help where necessary by questions to aid individual students to think through their difficulties. All twenty students can be helped more or less and considerable time can be devoted to one individual if necessary during the recitation period.

The amount of blackboard work can be varied from a few minutes only at the beginning of the period in order to see where difficulties lie, to a large portion of the period in order to carry solutions through to completion. In any case, however, class discussions are desirable before the students are dismissed at the end of the period.



IDEAL CLASSROOM FOR ENGINEERING MECHANICS

A powerful motivation for daily study is afforded by the realization that no student will be overlooked in this blackboard work. When the blackboard space is insufficient, a chance can be taken by any student of being missed. Even if the one so missed has studied the assignment, he fails to get the help of the teacher on that day.

By daily study of the printed page, the student develops the study habit which will be of help to him in practice when he finds it necessary to master a subject without first listening to a lecture upon it.

Certain tricks might be resorted to with a large group to accomplish the same results but with less assurance of success than in a small class. For example, a short written quiz might be given at the beginning of the lecture period to induce study of the daily assignments. But the same thing can be done with a small class with the further advantage that the teacher by observing individual students and moving among them can get a better idea of where difficulties lie than with a large group.

Lectures and demonstrations are desirable with small sections as well as with large groups of students. With small sections, however, lectures and demonstrations may be interposed with recitations and blackboard work whenever it may appear desirable. It is not necessary to have any fixed number of lectures every week.

In a lecture or a demonstration, the teacher may present a matter so clearly that students will think they understand the subject. But if tested by a practical problem it will be found that they cannot apply the principles involved because they do not fully understand them. In a small section, this test can be readily applied at any time and difficulties cleared up during the lecture period. In a large group, such difficulties may persist for an indefinite time. The delay between formal lectures to a large group and explanations in one quiz section each week with smaller groups causes the explanations to lose some of their value. It is doubtful if all the difficulties that develop during three lectures can be cleared up in one recitation.

In lectures and demonstrations, the small section permits more discussion by individual students than is possible with a large group. In a small section, the student feels more free to ask questions than in a large group. The students may be encouraged to ask questions at any time to clear up individual difficulties. They may also be encouraged to discuss applications of the principles involved. More interest can therefore be created in the subject.

In a small section, certain educational methods can be used which are impractical in a large group. Thus, with a small section when the roll is called at the beginning of the period, each student

can answer as to the problems he has been able to solve at home. The problems giving difficulty can thus be determined so that explanations can be concentrated on such problems during the period.

We therefore believe that our procedure of teaching mechanics of materials by dividing the students into small sections for recitations is much more effective in developing individual skill in solving engineering problems than by lecturing to large groups. We believe that the objective of the course should be the development of individual skill in solving engineering problems rather than the mere importing of information to the whole group. The student is not studying this subject simply to get a better understanding of the world around him in order to enjoy the more abundant life. The engineering student is studying mechanics of materials in order to design or to check the strength of engineering structures and machines. The safety of lives and property will later depend upon his skill in so doing.

Although we have never attempted to lecture to large groups of students in mechanics of materials, we have had to use classrooms with limited blackboard space, and we have found our teaching handicapped under such conditions. Our ideal classroom is one about 30 ft. by 25 ft. with blackboards around three sides and tables and chairs for twenty students. We have one classroom so equipped Each table is 18 inches by 48 inches supported on two cast iron columns bolted to the floor. This table gives adequate space for papers, reference tables, books, etc., in problem work and quizzes, as compared with the lack of adequate working space on the tablet arm chair so commonly used.

With sections limited to twenty students in such a classroom, a good teacher can utilize whatever teaching method may seem best at the time, depending upon the nature of the subject matter under discussion and the mental states of the individual students. The good teacher will soon become acquainted with the personal characteristics of the individual students and the individual students will feel a personal relationship to the teacher as well as a personal responsibility for daily preparation in acquiring a skill for solving engineering problems.

"SELECTION" OF ENGINEERING STUDENTS—DISCUSSION

By R. L. SACKETT

Dean Emeritus, School of Engineering, The Pennsylvania State College

Choice of engineering by a prospective student and his admission to an engineering curriculum are dependent on two important factors—viz., information on which the college prospect can make a judicious choice and, second, a selective basis for admission. Both are important to the boy who is supposed to help make the first decision, to his parents, to the high school which has helped to prepare him, to the college which admits or rejects him and to the engineering profession which he may expect to enter.

With all the books, pamphlets and articles which have been printed in the last decade, the problem remains much the same as it was when the "Investigation of Engineering Education" was published in 1929. At that time some fifty per cent of entering freshmen engineering students failed to graduate because of deficient scholarship, indefinite interest or lack of fundamental aptitudes and other factors.

In 1939 the same deplorable condition exists if one may judge from the fact that the present number of senior engineering students is about fifty per cent of the number of freshmen. Apparently no marked progress has been made in the counseling and the selection of applicants for the purpose of eliminating those who are such obvious failures in their first year of collegiate experience.

Counseling

It is clear that intelligent and understanding guidance by the high school is fundamental in any effective attack on the problem of selection. At the same time it must be realized that the position of counselor is a most exacting one and it is impossible for the most able high school adviser to be familiar with the details of the skills required in the 3,000 occupations listed, for instance, in the New York telephone directory. Many of these are closely related but to know which may be grouped together for purposes of occupational guidance requires unusual knowledge of job specifications.

The professions are so complex in their specialties that cyclo-

pedic knowledge would be required if it were not for the fact that the collegiate preparation is well defined and educational counseling is thereby simplified. Even then the legal and medical professions are proficient in counseling those who desire to know more about the requirements for and the diversity of lines of practice.

The engineering profession has not been as prominent in the public eye; less has been known about the expanding fields of its activity or the exacting character of its educational discipline.

The glamor of the radio, the airplane, television, rayons and plastics have tended to obscure the realities by the spectacular.

Furthermore, the engineering profession has not been so self-conscious as the other learned professions in protecting the public and itself from those not well prepared by education, character and experience to protect public health, life and property. Registration is a relatively new experience and the profession is becoming conscious of the new responsibilities created by licensing. Not only is the public to be protected by the profession but the latter must be alert to avoid those pitfalls which have harassed other professions.

How does this concern high school counseling? The engineering societies are becoming aware of the obvious fact that their standing depends on the quality of those who are selected for the first vital step—engineering education.

Selection begins with the guidance of the high school boy. If his counselor, teacher or principal who may be the guiding spirit has the three attributes mentioned in a study by the American Council on Education, he may guide the boy wisely toward or away from the engineering profession. These three fundamental attributes are "(1) a dependable analysis of the student's aptitudes and other characteristics; (2) a searching for college courses and occupational goals which appear to offer probabilities of success and satisfaction (by discussion between counselor and student, by the student's reading and try-out experiences or by an appropriate combination of all methods); and (3) a painstaking explanation by the counselor of these steps and of the desirable and tentative conclusions. As yet we are only approximating this idea." *

First, knowledge of the high school student's temperament, tastes, abilities and scholarship is of the essence of good guidance. No test, formula or hunch is a substitute. This is equally true of collegiate counseling and makes the difference between good and average aid to the needy.

Second, the appraisals of personal ambition, ability and fitness is the next requisite of excellent guidance in high school or col-

* *Am. Council on Ed. Studies.* "Occupational Orientation of College Students," April 1939, page 38.

lege. It is a test of the skill of the guide in assaying the potential qualities of the boy.

An interest test may be of help by furnishing a basis for organized attack on the problem of differentiating between the requirements of various trades or professions and the fitness of the boy for one which he fancies.

Third, the patient explanation of what is required to fulfill the studied purpose of the student. The emphasis should not be on mathematics only or on any other subject no matter how important it may be in the engineering curriculum. If the boy is not fitted for engineering he should have all the requirements placed emphatically before him. Kindly advice is warranted when the obvious qualities of the boy do not meet the requirements of the proposed trade or profession. As the report of a committee of the American Council on Education says, "As yet we are only approximating this ideal" in collegiate educational counseling or high school guidance.

Engineers Council for Professional Development

The Committee on the Selection and Guidance of E. C. P. D. is attempting to supply more adequate and reliable information on engineering education and the profession. The method is to organize committees of engineers in each community to coöperate with high schools in providing conferences of interested high school students with men of experience and understanding who are interested in local boys and in the future members of the profession.

The purposes of E. C. P. D. are so new to the engineers who have been absorbed in the technical discussions that their appreciation of the importance of counseling, selection, the advancement of recruits and the recognition of the profession is delayed. Slowly, local sections are becoming alert to self-interest and service to local boys by organizing guidance. Where such efforts have been made, they have been welcomed by the high school principals, by students and by parents. Numerous cities have effective organizations and one illustration will suffice to show what is possible. In New York City and environs, 14 high schools have been addressed and 1,500 boys have been counseled concerning engineering during this school year.

"Engineering: A Career—A Culture" is being widely used by high schools, colleges and committees of engineers who are coöperating in guidance. A year has been devoted to revising the pamphlet and it is hoped that it may be published at an early date as the first edition of 100,000 copies is nearly exhausted.

Selection

The selective process on which to base the admission of students to college is of both economic and social importance. The financial burden of education is such that the kind of preparation for life should be such as best fits the individual for usefulness and the greater measure of happiness that goes with the harmony of ability and job. While some good adheres to anyone who goes to a university for a year or two, guidance and selection should provide a greater degree of benefit from that form of preparation for life which best fits the human compound of attributes for the future.

At present, admission to college is possible in some parts of the country if one has graduated from a high school which is accepted, accredited or approved by the state or by the college. Many privately endowed institutions have required applicants to pass college board examinations. A few state and private colleges require high scholarship averages for admission. Still fewer depend on interviews to assist in further selection of those most likely to profit from this type of mental, moral and physical preparation.

Differentiation of attributes is still in the experimental stage but the evidence is accumulating that broad differences in aptitudes and tastes can be measured. Certainly there is a keener interest in the subject and hopes are entertained that the American Council on Education will attack the problem vigorously and evaluate the various studies which are being made.

There are two classes of approach to admission. One is to discover by achievement tests the degree of preparation in certain fundamental subjects which the student has now in his possession.

The other and more difficult one is to discover aptitudes which mark the student as best fitted for one general division of study and subsequent practice in that field.

The first, or tests of present preparation as distinguished from variable high school standards, are well established. The coöperative tests, the Iowa Placement Tests and others are examples.

The detection of special abilities has been explored at the University of Ohio, Minnesota, Yale, Stevens Institute and by many individual investigators.

The study of visualization is one of the most desirable attributes of the engineering type of mind. Descriptive geometry, the Minnesota Form Board and variations have provided material for analysis. No doubt this aptitude can be relatively measured. However, this quality of objective imagination is of value to others than engineers. How much weight should be given its presence, its absence or a high degree of the gift? It seems clear that it can

be cultivated. Added to the discovery of its latent presence there might well be considered such measures as will develop it. This aspect of education has been largely neglected except for the engineering students. The halting progress of many during the first few weeks of the study of descriptive geometry indicates that there has been an oversight in the study of both plane and solid geometry where the rudiments of visualization ought to be made conscious.

E. C. P. D. has helped to demonstrate that the coöperative test in mathematics has good predictive value for reasonable progress in the usual engineering curriculum. The histories for four college years of some 3,000 entering freshmen engineers have demonstrated its reliability.

The Strong Interest Test is of value in interviewing those of uncertain objectives because it furnishes a basis for systematic discussion. The question of how permanent the interests of a student are at that stage of his career needs further study. Perhaps it is beyond prognosis and it must be viewed with caution by those who use it, depending on the degree of stability which the student exhibits.

There still remains the question of whether past high school records or present examinations are adequate criteria for admission. There are exceptions and the methods of elimination should be flexible enough to provide for the admission of the applicant who fails to top arbitrary hurdles, but has essential interests, aptitudes and certain scholastic preparation which is fundamental. The methods of exploring the unstandardized is no better than the provision for them to proceed if admitted. Standardization, when carried to the point that it ignores personal differences, tends likewise to submerge the individuality of the institution, its faculty and its curricula.

Tests of scholarship and of aptitudes are available, but none of them is infallible; all are subject to the habits and skill of the person giving them and the interpretation of results is likewise open to differences of conclusion. Their use must be mixed with judgment where a knowledge of the student is valuable in counseling.

The greatest advance has been in the counseling of those already admitted to college to determine where those doubtful ones belong who show early signs of not being properly equipped for what they have undertaken.

Even here the counseling is far from well-organized, the psychologists being sometimes too much wedded to their instruments

of diagnosis, and the engineers are often too skeptical of the help that rudimentary psychological tests might give them.

Finally, selection at the end of one or two college years is hope deferred and often it is faith destroyed in the young, ambitious, hard-working but ill-prepared student who finds himself floundering in a troubled sea. Better counseling as a first step in intelligent selection and measures designed to indicate proper equipment for admission are greater needs today than is generally recognized. Better students are more important than more students.

CORRECTIONS

On page 537, January JOURNAL OF ENGINEERING EDUCATION, Reed and Corcoran's "Electrical Engineering Experiments," John Wiley & Sons, Inc., is priced $2.75. This is incorrect. The price is $4.50.

"Storehouse of Civilization" by C. C. Furnas, reviewed in the January JOURNAL, page 534, is published by the Bureau of Information, Teachers College, Columbia University, New York City, price $3.25, 562 pages.

F. L. BISHOP, *Editor*

Quoting from page 370 of the December JOURNAL: "L. A. Doggett questioned the necessity of teaching design courses at all. He pointed out. . . ."

The above abstract of my remarks is misleading. From the above it might be inferred that I do not look with favor on design courses, whereas the fact is that I am an ardent advocate of design courses.* The writer wishes to be on the record as believing that the general philosophy of design is an absolute necessity for the engineer of all types. In particular, design courses provide for the electrical engineer an intimate knowledge of the "innards" of electrical machinery just as anatomy courses provide the same sort of knowledge for the medical student.

Yours very sincerely,

LEONARD A. DOGGETT

* Vol. XXI, No. 7, March, 1931.

CIVIL ENGINEERING PAGE

Notes of interest for members of the Civil Engineering Division.
—Editor, EDWARD E. BAUER, *University of Illinois, Urbana*

M. W. FUREE, *Chairman*
F. T. MAVIS, *Past Chairman*
PAUL P. RICE, *Secretary*
EDWARD E. BAUER, *Editor*
L. G. STRAUB
F. W. STUBBS, JR.
H. T. HEALD

NEEDS FOR RESEARCH IN THE BUILDING INDUSTRY

By JOHN ELY BURCHARD *

At the outset permit me to omit consideration of the substantial research in structural analysis and general behavior of materials. These fields are being aggressively explored and need no comment here.

There are many things about the building industry which it would be interesting for us to know in the sense that it is always interesting to know more about anything. Some of these interesting unknown facts, if brought to light, might in turn serve as ammunition for men of action. Confirming as they might certain long-suspected truths, their establishment on an impartial and reasonably accurate basis might lead to some needed convulsions in the political arena. But the matters with which I shall deal seem to have immediate application.

1. *Social-political-economic studies*

For nearly fifty years the building industry has been the butt of industrial criticism. The most familiar cliché runs: "There *is* no building industry." From the point of view of a production-line manufacturer, the statement seems valid. Moreover, it must be conceded that building is a topsy-turvy industry. What other industry distributes its products through scattered brokers? In what other industry are the parts makers the largest commercial factors? What other industry pays labor to think instead of to act mechanically? In what other industry do costs inevitably rise with increasing production? The limping details are all too apparent to anyone. The conclusion has perhaps all too freely been

* Director, Albert Farwell Bemis Foundation, Massachusetts Institute of Technology, Cambridge, Mass.

Condensed from a paper presented at S. P. E. E. Civil Engineering Division Conference on Construction Education at State College, Pa., June 1939.

drawn that the industry is perforce inefficient in every fibre and sinew, a pariah among the holy people of modern efficient industry.

It would be illuminating for us to have definitive studies of the progress of building costs, of the changing productivity of building labor, of the methods of distribution in the industry and what these methods cost as compared with those of the chain store, the automobile manufacturer or the A. A. A. Granting that archaic codes offer a general barrier to progress, specifically what have they cost us so far? What is the cost to the industry of the recalcitrant craft-union system? When these and other studies like them have been made, they should show more clearly than we now know the areas in which concentration of endeavor would seem to offer the widest possible marginal gain.

There are other studies which may seem to you less remote in their interest. Investigations of community and neighborhood trends, of land economics, of the municipal tax problem, of methods of financing buildings, of the real advantages and disadvantages of tenancy and ownership, all should prove fruitful.

2. *Studies of building materials*

This is one of the two classifications of building research in which industry is prepared to take, and has in fact taken, a hand. The manufacturers of building materials have substantial research laboratories whose work is of the first class. Their studies will ordinarily follow the pattern of developing new materials or by improving old ones. Such work is engaged in not only by the well-trained staffs of the industrial laboratories but also by competent workers on the staffs of trade associations and in one outstanding case of an agency of the Department of Agriculture. As a result there has been a fairly steady improvement in the performance of some materials, notably of paints, of metal alloys, and of glass. There has been a reasonable growth in new materials for building, though few revolutionary ones have been provided.

There are people who believe that no substantial improvements in building techniques can be achieved with present building materials or their evolutionary modifications. They have sought, do seek, and will seek some perfect new material which will make the needed improvements possible. They say, and in this we can perhaps agree with them, that present manufacturers of building materials and their laboratories cannot be expected to produce the revolutionary new material or materials.

But with the idea that such new materials are the crux of the matter I cannot concur. Moreover, such observations of the workings of research as I have been able to make suggest to me that if such materials are developed they will not come as a result of con-

scious effort to make them but more likely as the result of collateral developments in which perhaps even the touchstone itself has been created originally for a different purpose.

There is another aspect of research on building materials which lies relatively neglected. The work on behalf of the producer is well organized and effective. That on behalf of the consumer languishes. This consumer, be he owner or banker or designer, has a substantial stake in how his building will behave. If he has any progressive spirit he is not content to play safe by always using materials which have "stood the test of time." But he does need some objective way of comparing materials which essay to perform the same function. Omitting the non-objective criteria of appearance, all of the others can be related to economics; the comparison may rest on a proper balance between first cost and maintenance cost, the latter of which is a function of durability.

The problem here is twofold. In the first place, the technique by which comparative economic performances of materials can be evaluated remains to be fully developed. This is a problem for research.

The other part of the problem is less one of research than of public relations. Who is to publish these data? Can a national governmental agency like the Bureau of Standards do this job and be free of all sorts of interferences, by no means all of which will be confined to the work which has offended some interest? Is it the job of an educational institution? I do not presume to answer this, but merely to place the question before you and to remark that proper consumer standards for building materials would do a great deal to improve the quality and the economic life of our buildings.

3. *Studies of building productivity*

In the desperate effort to bring costs of housing down there have been literally thousands of ideas tried in the arena of actual construction. Some have apparently saved money. Some have been potentially able to save money. Yet they have been the subject of little more than rumor and loose statement.

The difficulties here lie deep. Building costs other than indices as published to-day mean nothing or less than nothing. Until a system of cost accounting similar to that imposed by manufacturing industry on its operations can be applied to those parts of building production under scrutiny, useful comparisons cannot be made.

There are naturally many other kinds of studies which might be made in the field of building productivity. But until normal processes of building production are subjected to the same sort of scrutiny as the processes of the production line, not much progress can be expected.

4. *Studies of amenities*

Despite the strong emphasis which is being laid in public on low-cost buildings for the purpose of housing our ill-housed, it must be apparent that all the progress in the building industry should not be attempted solely in the field of reduced cost. Evidently there is equal and perhaps greater opportunity to make our lives more pleasant and freer from strain in these buildings of ours.

It seems strange that radiant heating, no very new principle if we consider the houses of history, should only in the past few years have attracted serious attention. Thus physiologists like Dr. Winslow at Yale are able now to lay down principles of comfort which are expressible in terms of measurable factors—objectively measurable factors. This widens the scope of heating investigations remarkably. Similar things are occurring in illumination.

But actually our studies in this sphere can be still broader, still more naïve. It would not hurt for some very simple but also some very thoughtful people to sit down for example with the window in mind and carefully write down all its functions. It would not hurt for these same people then to forget what has been done to satisfy these functions and, starting only with existing materials and existing manufacturing techniques, see what sort of device might best serve the functions.

The synthesis of the view designs into a new and efficient design for the whole building would be a natural sequitur. The advantage of this approach to the redesign of the building is that the final product even though it may appear most unconventional will be defensible on scientific grounds and any debate may be removed from the field of aesthetics on which so much discussion of current modern architecture has bogged down.

5. *Studies in integration*

Some aspects of integration of materials and amenities and methods into a building are closely studied now. We need have no concern, it seems, over the quantity or quality of the work which examines new possible structural methods. The details by which clothing materials are applied to the framework is a matter of more concern.

Of all the planning and integration studies which have been made for the building, perhaps the most fruitful have been those concerned with equipment. Kitchens and bathrooms particularly have gone a long way towards the sort of integration which is characteristic of other industrial patterns. Research of this sort will continue and will in general be the concern of industry rather than of the university.

But there is an aspect of integration which does demand research, research of a somewhat pedestrian sort, but nonetheless important for all that. It might for want of a better term be called architectural research.

We live in an age when almost every building has highly specialized technical requirements. Yet with these expanding technical requirements there are but few types of buildings which are built with sufficient frequency so that as a practical matter any firm of architects can afford the time to become true experts on the problem. The architect then finds he has a client who is unwilling and probably unable to pay for elaborate research and who moreover wants the building built at once. The client is quite often reasonably expert himself on the subject at hand.

But the achitect if he is to perform his function properly must above all be the master selector. He is employed to discriminate, to contrive a building which above all works smoothly and which moreover is not merely the smooth-working version of today but which casts some eye at the techniques of tomorrow. This poses a dilemma.

One possible solution to this dilemma lies in architectural research—in the study by graduate fellows in architecture of the special requirements of special kinds of technical building—by consultation with each and every qualified expert—by coördination of these opinions—by lucid presentation of the whole—all of which might like scientific papers of other sorts appear in due course as a monograph. I wish not to be misunderstood on this point. I do not urge that these research workers create solutions for hospitals, and theaters, and railway stations. Their work should result in no personal interpretation of the requirements but merely in the lucid statement of those requirements on which others may build personal interpretation. In such research lies a splendid opportunity for one kind of integration the building industry vitally needs.

ENGINEERING ECONOMY PAGE

Engineering economy is that phase of engineering work in which technical plans and operations meet the critical and constructive tests of applied economics.

EDMUND D. AYRES, The University of Wisconsin, *Editor*

A REPLACEMENT PROBLEM FORMULA

The discussions of the replacement problem appearing on this page have prompted the writer to present a method of developing this problem which he has used with his students. The conclusions reached do not differ from some of those presented by others; but a simple algebraic proof of the values to be used in the replacement problem has not previously appeared here.

To proceed with the development, let us assume that an old machine has been in service for a known or an unknown number of years; that its remaining useful life and its final salvage value are estimated; that all yearly costs such as taxes, insurance, operating expenses and maintenance are known and will be uniform throughout its remaining life. To calculate depreciation and interest, it is necessary to place a value upon the old machine on which to base these charges. This value may be "book value," "wearing value," or any other value considered appropriate:

Let A = present appraised value of the old machine.
S_0 = salvage value of the old machine at end of its remaining life.
d_0 = depreciation rate for the remaining life of the old machine, preferably on a sinking fund basis.
i = interest rate.
O_0 = all yearly expenses for the old machine except depreciation and interest.

Then the total annual cost of the old is:

$$Y_0 = (A - S_0)d_0 + Ai + O_0 \tag{1}$$

Assume further that a new machine proposed to replace the old has known uniform yearly costs; that its useful life, equal to or greater than the remaining life of the old, and its final salvage value are estimated; and that the service given by it is substantially the same as that given by the old:

Let C = first cost of the new machine.
S_n = salvage value at the end of its life.
d_n = depreciation rate for the life of the new machine.
i = interest rate.
O_n = all yearly expenses for the new machine except depreciation and interest.
S_0' = present salvage value of the old machine.

If the new replaces the old, the difference between the present appraised value of the old and its present salvage value is the loss in value due to replacement. This difference may also be thought of as the remainder of a debt incurred by the

purchase of the old. By some it is given the mouth-filling name, "unamortized value."

Considered either way, the difference must be recovered from savings resulting from installing the new, if the replacement is to be economically justified. To recover this difference, an equivalent annuity is charged to the new for the remaining life period of the old.

The total annual cost of the new for this period would then be:

$$Y_n = (C - S_n)d_n + Ci + O_n + (A - S_0')(d_0 + i) \tag{2}$$

and the difference between the yearly costs of the old and new would be:

$$\begin{aligned} Y_0 - Y_n &= [(A - S_0)d_0 + Ai + O_0] \\ &\quad - [(C - S_n)d_n + Ci + O_n + (A - S_0')(d_0 + i)] \\ &= [(S_0' - S_0)d_0 + S_0'i + O_0] - [(C - S_n)d_n + Ci + O_n] \end{aligned} \tag{3}$$

It will be observed that the present appraised value of the old machine subtracts out in finding the difference between the yearly costs. It is, therefore, unnecessary to consider such a value since the difference in costs is the item which finally concerns us. We may more simply write that the annual costs of the old and of the new for consideration in the simple replacement problem are, respectively:

$$Y_0' = (S_0' - S_0)d_0 + S_0'i + O_0 \tag{4}$$

and

$$Y_n' = (C - S_n)d_n + Ci + O_n \tag{5}$$

Neither of these costs, Y_0' or Y_n', is the actual cost under the conditions assumed. Both actual costs for the period considered have been reduced by the same amount. The difference in cost is not changed thereby but the calculations and other work are simplified. The only investment values used for the old are its present and future salvage values. Its original cost, years of previous service, depreciation rate, "unamortized value," or sunk cost are quantities that are not needed. On account of this simplification, the abbreviated values given in the last two equations are used instead of the actual costs.

E. H. FREEMAN,
Armour Institute of Technology

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*, University of Virginia

VII

UNUSUAL PLANS AND METHODS IN ENGLISH *

By KARL O. THOMPSON

Professor of English, Case School of Applied Science

The investigations of the Committee on English have brought out several interesting departures from what might be called the normal procedure in teaching English in engineering schools. It is the province of this chapter to present some of these plans, partly as a record of the work being done, but chiefly as suggestions for schools that are able and willing to experiment a little.

Although previous studies by Professor A. M. Fountain † of the North Carolina State College and Professor W. O. Birk ‡ of the University of Colorado have shown a great variety of course names and of subject matter taught by departments of English, it is probably quite accurate to list the following as the normal or usual courses, credit for which would be accepted by deans in transferring students and interpretation of which would be comparatively uniform.

English Composition (or Freshman English)
Theme Writing
Survey of English Literature
Technical Writing (sometimes more specifically):
    Business Letters
    Report Writing
American Literature
Contemporary Literature
Public Speaking

* This is Chapter VII of the Report on Instruction in English in Engineering Colleges.

† Fountain, A. M. "A Study of Courses in Technical Writing," Raleigh, North Carolina (1938).

‡ Chapter VI of this Report.

Courses with these names conform to the three-fold objective that has come to be applied to courses in English in most engineering colleges: (1) to give students practice and skill in writing clear and accurate English; (2) to acquaint students with what has been going on in the world through the best books in the English language in the fields of literature, biography, travel, science, and philosophy; and (3) to afford students some training in oral expression. Modifications of the usual courses do not depart from these objectives, but strive in and through their differences to accomplish the same purposes.

Experimentation is probably easier in the institutions that have autonomous departments of English, for the mingling of liberal arts students with engineering students or of other professional groups with engineering classes complicates special adaptations of methods or material. Experimentation, also, depends upon the availability of personnel and time. Some courses that are different have originated with outstanding personalities; among the pioneers in the field were Professor S. C. Earle of Tufts College, Professor W. O. Sypherd of the University of Delaware, Professor H. A. Watt of the University of Wisconsin, Professor J. R. Nelson of the University of Michigan, and Professor J. M. Telleen of the Case School of Applied Science. Sometimes local conditions have given a kind of "set" to courses, and sometimes the historical background of an institution has started instruction along a certain line.

We are now ready to look at courses that have been unusual either in content, in classroom methods, or in their relation to actual engineering work. We shall try to inquire into the purposes back of the unusual courses, with the implication that they might be selected for trial by other schools. The discussion will relate to individual courses rather than to departments or to institutions as a unit.

I. Courses That Vary the Subject Matter from That of the Normal Type of Course

Not many colleges depart from the subject matter of Freshman Composition, usually given in the first semester and often throughout the first year. There is, however, considerable variation in the use of textbooks, some preferring a handbook, which is essentially a reference book, and others selecting a discussion of composition or the four types of writing, a book much like the older rhetorics. A few use a text that has many specimens that can be studied and analyzed. The use of practice leaves, loose-leaf notebooks for exercises, correction charts, etc., does not really constitute "unusualness," because they are all devices to make instruction in grammar,

punctuation, and spelling as painless as possible and as interesting as may be to the students. The big problem is to give proper motivation to avoid monotony and drudgery.

For many years the Case School of Applied Science has used the subject matter of argumentation and debate as the chief material for the first term of the freshman year. An attempt has been made to give a course distinctly different from high school English and to gain motivation by discussing current problems and by employing the fundamental method of analysis associated with engineering. Theme topics grow out of class debates, correctness of writing being checked against a standard handbook. This type of course also permits the faculty to offer supervised oral work early in the student's career.

The Massachusetts Institute of Technology includes special items with composition in the first term, such as preparation of patent specifications, description of a mechanical device, and the use of the library. Beginning with the second term, three parallel courses are open, one of which must be chosen. The three courses are Modern History, American Literature, and Scientific Thought. The same system of grouping is continued in the sophomore year, but changes from one group to another are allowed and even recommended, the theory being that the student will profit by acquaintance with at least two of the groups. As a matter of fact, the preferences are about evenly divided without faculty adjustment. Considerable written work in both long and short themes is required in each group, with, of course, a high standard in composition. Many of the staff are trained in history.

The usual course in literature is varied more frequently. The University of Virginia requires a study of great books through lectures and reading, the purpose being to present materpieces of world literature rather than to keep to the narrower field of English and American, and also to stimulate independent reading both in college and after graduation. The historical framework is much restricted, as compared with a survey course. The California Institute of Technology also has had success in stimulating non-credit reading, in their case through lists of books for summer reading, recognition for which is an extra-curricula credit. A course in Modern Literature is required at the University of Maine, and Rensselaer Polytechnic Institute has an elective in Comparative Literature. The Virginia Polytechnic Institute gives a course in Southern Literature, making an appeal to local pride as well as recognizing that the literature of the section from which many students come and in which many graduates will reside will have special value to the people of that region. Other sections of the

country might well find similarly rich bodies of literature that could be used as course material.

Special forms of literature, such as the essay, the short story, the novel, or drama, are given definite place in many schools, probably on the theory that high schools give a survey course in literature and the college may well build more specialized courses on that foundation. Most schools give separate courses; a few combine two or more into a Types of Literature course. The Case School of Applied Science has a separate course for the Essay, required in the second semester of the freshman year, and a Types course that includes drama, poetry, and the novel, in the sophomore year, also required. Only a very few separate courses in poetry are found. The Polytechnic Institute of Brooklyn and the Massachusetts Institute of Technology recognize the value of play production in teaching literary appreciation, for both offer valuable training in play writing, play production and direction, and acting. The Carnegie Institute of Technology also does a great deal in play production but it is not limited to the engineering students and for them would be an activity, as it is in many other institutions. Frequently elective courses in play reading and classroom discussion of plays appear.

Weakness in vocabulary is a point that has brought frequent criticism upon engineers, but hardly an institution mentions any course designed to correct this fault. Perhaps it can best be overcome by incidental drill in some course in literature; surely vocabulary study ought to find a place somewhere. The English faculty at the Case School of Applied Science emphasizes vocabulary study in the course on the Essay. Vocabulary tests are given in almost every session of the class, with repeated emphasis on the use of a dictionary. The California Institute of Technology has found that essays used in such a course should not be exclusively scientific. From the point of view both of vocabulary and of student interest, the essay should be general in subject and inclusive in period.

Under the general heading of Technical Writing, several schools vary the usual textbook and long-paper type of instruction by furnishing current technical periodicals or documents from actual files. Washington University, North Dakota Agricultural College, the University of Maine, and Montana State College use scientific or engineering periodicals; Case School of Applied Science uses one to supplement the textbook; Armour Institute of Technology, the University of Hawaii, the University of Maryland, the University of New Hampshire, and the South Dakota School of Mines secure fresh reports and letters to supplement textbook specimens. The Ohio State University has used a business man's approach through letters and reports to secure student interest.

Armour Institute of Technology introduces a course in logic in the sophomore year, which is made to tie in with scientific theory and writings. This approaches one of the parallel groups mentioned in the course at the Massachusetts Institute of Technology. There seems to be no reason why a department of English should not adopt the theory that writing and thinking as found in science can assist a student in developing a satisfactory style of his own.

At least two institutions combine literature and composion in the same course in interesting ways. The California Institute of Technology lists a course entitled "English Composition and Reading," in which essays and short stories are used as the basis for teaching composition. The United States Naval Academy and The Polytechnic Institute of Brooklyn also combine literature with some technical writing in one course. The time factor may lead to such a combination, and, of course, creative writing, whether technical or literary, can be closely related to specimens that are noted for their fine qualities of style.

Another type of course that is found replacing the more usual survey course is one that can be labeled History of Civilization. In many schools such a course is in addition to the normal English course and is taught by a separate department—history, social studies, or a combination of engineering staffs. Orientation courses or engineering background lectures are involved here, as well as a straight course in history. If such a course is taught by the department of English, an effort is made to teach style and correctness in the mechanics of composition through the papers required to accompany textbook or lectures. The Carnegie Institute of Technology has such a course under the department of English. Union College gives to its engineering students a course in Engineering Lectures covering the history of engineering, present day achievements in engineering, and the professional aspects of engineering.

As with the Massachusetts Institute of Technology, a few schools put courses in history on the required list. The Alabama Polytechnic Institute gives a course in the History and Government of the United States; the Carnegie Institute of Technology gives Civilization in the United States, with special reference to the period following the Civil War; and Armour Institute of Technology offers a course in Contemporary Problems. In some cases such courses are electives, or are electives under certain conditions of schedule; in several, however, they are the required work in English either first or second year.

Public Speaking varies chiefly in the amount of time allotted to it. Some schools have complete textbooks of theory, others use only a project book. The purpose in all is undoubtedly to give a maximum of supervised practice to the students.

II. Courses That Present Unusual Classroom Methods

There are a number of instances in which the usual order or sequence of courses is changed. Stevens Institute puts its course in literature in the freshman year and its course in composition in the sophomore year. In the first year at Yale University, literature is required of all men and is continued in the second year. At the University of Rochester, literature is an elective for all except engineering students, but is required of them in the freshman year. Purdue University puts its Advanced Composition in the junior year.

Two variations in handling technical writing are found; in the University of Florida, a writing laboratory, with projects of the students' own choosing, is conducted, and in the University of Idaho, two long reports are made the center of instruction. The former arrangement is not limited to engineering students, and the latter is used to extend the personal contacts of the students with practicing engineers and available books in the field chosen.

A number of colleges have a systematic plan of individual conferences with students to see that classroom procedure is both understood and applied. This plan can be used with any course material. It is a means supplementing the desk or textbook instruction and often involves the comprehensive examination; in some non-engineering colleges it develops into the seminar or project program wherein the student's work is largely individual or supervised research. Conferences are not found in this extreme use in any engineering school, so far as noted. The University of Cincinnati, Cooper Union, Tufts College, and the Massachusetts Institute of Technology have all developed the conference plan in a thorough and consistent way as a requirement. The Carnegie Institute of Technology requires regular conferences with senior students over the written work prepared in the technical departments. Probably all teachers of English have occasional conferences as circumstances demand; these do not figure in teaching loads as such. The tendency is unquestionably to place more emphasis on conferences as a means of teaching, but the problems of time and teaching load complicate the matter.

Purdue University has been successful with the recall provision, whereby all written work in the junior and senior years is subject to perusal and criticism by a special Committee on English that may (and does) require additional instruction and work and even prevents graduation until satisfactory performance is reached. The remedial work given the student depends in amount and in difficulty on the nature of his trouble. The principle here involved is one that is sound pedagogically, the difficulties being those of

schedule and teaching load. There is also a possible difficulty in winning the consistent coöperation of the members of the engineering staffs. It has a distinct advantage in being applied after students have passed the required English of the first two years and of reaching transfer students who have come after the required work has been credited to another institution. There are valuable points in a plan like this, particularly if it can enlist, as it does at Purdue University, the active assistance of teachers outside the department of English.

Required courses in English are almost everywhere limited to the first two years; offerings beyond that period are electives. Almost every engineering school gives optional courses, sometimes bracketing cultural and non-cultural courses together, sometimes (and more soundly) requiring an election from a list of humanistic subjects. The aim, of course, is to extend the range of information of the student to non-engineering fields and to allow the development of individual interests and abilities. A few electives are admittedly "tool" courses, but much more frequently the electives do not contribute to engineering skill or professional efficiency. A great variety of elective courses has been noted, involving almost as great a variety of classroom methods. Probably a sound principle to follow is that an elective should not be offered unless there is a man on the faculty well qualified to teach it. An elective simply for the sake of an impressive list is bad psychology. Departments of English do not often contain men who can go outside the field of literature for offerings, but wherever there are men trained in history, social studies, journalism, psychology, or speech, such teachers should be allowed and encouraged to present their elective courses. The most extensive list of electives in any one institution, so far as discovered, is that at the Massachusetts Institute of Technology; but here, it must be remembered, history, scientific thought, and the fine arts are the normal assignments of the department of English. It may be well to give the list, to show what can be done, if personnel and teaching loads permit. For a few of the electives, faculty members of other departments are drawn upon, and that situation would be more definitely true in other engineering schools. The electives are grouped under four heads: History of Science and Thought, History of Civilization, Literature and Fine Arts, and Social Sciences; these are indicated by number in the list.

I. History of Science
History of Mathematics
Problems of Modern Philosophy
History of Philosophy
Biography in Science
Descriptive Astronomy

II. The United States and Latin America
History of Engineering
History of the Far East
The Social and Industrial History of Modern Europe
The Social and Industrial History of the United States
Military History and Policy of the United States
Development of Navigation and Cartography
Economic Geography

III. Advanced Composition
American Literature
Contemporary European Literature
Contemporary English Literature
French Literature
German Literature
German Fiction
Dante in English
Public Speaking
The Bible as Literature
Shakespeare
Literature and the Fine Arts
Design in Manufactured Products
History of Music
Introduction to Music

IV. Introductory Psychology
Study of Human Relations
Comparative Political Institutions
Comparative Economic Institutions
Introduction to International Relations
Principles of Sanitary Science and Public Health
Biological Reproduction

The University of Washington offers electives under the four headings: (1) The Physical Environment, (2) The Biological Environment, (3) The Social Environment, and (4) The Cultural Environment.

Other engineering schools offer period or type courses in English and in American literature, such as the Short Story, Modern Drama, etc. The United States Naval Academy offers a few elective courses appropriate to its general purpose, such as Naval History, and American Diplomacy. The Polytechnic Institute of Brooklyn has one with the title "Human Relations and the Integration of Character." Practical courses in business letters, report writing, thesis writing and public speaking are fairly common.

Through elective courses a school may set up a wide range of study; frequently the possibility of electives determines the nature and content of the required courses.

III. Courses That Are Supplemented in Unusual Ways

Several institutions separate their students at the outset of the college year into different levels and give them simultaneously somewhat different work. In some, two levels and in others, three levels are determined, usually by placement tests. One of the most carefully worked out plans is that at the University of Oregon, where three groups of entering students are formed. The highest level men are not required to take the work of the first term and the lowest level men are given sub-freshman work. The center of average group carries three terms of required English. Changes from one level to another may be made at the ends of terms if the circumstances warrant, but the course contents are distinct. Variations of this plan are used at Purdue University, Armour Institute of Technology, Louisiana Polytechnic Institute, and Georgia School of Technology. In some cases the lowest level students are given fundamental grammar drill without college credit; in other cases the review work is given full college credit. Problems of make-up work, repetition of course, and acceptance of credit often complicate not merely the office bookkeeping but also the actual accomplishments of the students.

Swarthmore College has met the difficulty by giving up all required courses. Both composition and literature are, of course, offered as electives. Any deficiency in writing in later terms is met by assignment to one of these elective courses in which creditable work must be done.

The Alabama Polytechnic Institute prescribes a tour of inspection of industries and business; the required writing is then based on the observations made on the trip. Union College has brought the use of a reflector lantern into the classroom, by means of which actual passages from student papers are thrown on a screen for analysis by the class as a whole. A number of schools, notably the University of Washington and the Iowa State College, coöperate with engineering departments in student written work, beyond the first year. In the latter institution the theme subjects are selected by the staff in electrical engineering, who insist upon accuracy in technical matters; the papers are then graded by the English staff for excellence in composition. Similar coöperation, but on a smaller scale and less systematically, is followed in several schools in the course in technical writing. Publication of excellent student papers is encouraged in some places, and if the school publishes a technical magazine (as distinct from a college newspaper), publication of student work is very commendable. Coöperation with some local engineering firms or even with city government departments has been carried out sporadically. There are fine possibilities in

these ways to give reality to student work. Likewise in public speaking, students have been sent to groups such as society meetings, fraternal organizations, political rallies to speak about scientific or civic problems.

The inclusion of courses in modern languages is, perhaps, not a proper part of this survey, but all the possibilities are found, from the extreme of no modern language at all, at Stevens Institute, to the other extreme of as much as six credit hours, at Armour Institute of Technology, the Polytechnic Institute of Brooklyn, Clarkson College, the Carnegie Institute of Technology, and Rose Polytechnic Institute.

This chapter has presented interesting experiments in teaching English at engineering schools. The reasons for variations from normal courses have been discussed in brief. All this has been done in the hope that English courses may escape the criticism of being dull and that men in charge of English instruction may find ways to add new appeal to their most vital contributions to the engineering profession. The assumption of responsibility for training engineering students in effective writing is recognized by departments of English generally; they would not be willing to assume this responsibility alone, for everyone knows that teachers of engineering subjects can nullify much of the work of the English teachers, just as do certain home conditions and working environments. The spirit of coöperation on the part of teachers of English with the program and methods of engineering is also to be encouraged. The two groups of teachers can work together in carrying the high ideals of the engineering profession and the essential qualities of good citizenship to their students. The world of the engineer is large enough to include some of the humanities and the fine arts, and teachers of English can do much to make the prospective engineer conscious of the value of these fields and to prepare him to enjoy them.

MECHANICAL ENGINEERING PAGE

Those who personally dominate are heroes for the hour; those who build men are immortals.

R. L. SWEIGERT, Georgia School of Technology, *Editor*

With the passage of time it is becoming more evident that we should take stock of graduate courses in Mechanical Engineering and their relation to the undergraduate curriculum. A large proportion of the undergraduate mechanical engineering curricula contain specialized undergraduate courses, even though the emphasis in discussion has been upon the inclusion of fundamental courses and the elimination of the specialized courses. Would it be more desirable from the viewpoint of graduate work to eliminate the specialized work completely from the undergraduate curriculum and thereby allow more time for truly fundamental courses which will prepare the student better for industry and for graduate work? Would it not enable us to develop graduate work of a higher caliber? Professor Ham presents some points on graduate work in Machine Design. It appears that answers to the questions above might be related to part of Professor Ham's discussion. The discussion follows.

GRADUATE WORK IN MACHINE DESIGN

By Professor C. W. Ham, University of Illinois

A study of the catalogs of the colleges and universities in this country reveals, as one might expect, a great variety of procedures regarding graduate work in machine design. In some cases graduate courses in machine design are not mentioned. At the other extreme, a rather extended list of such courses is given. In the former case it is probable that graduate work related to machine design is available in other fields, such as Mechanics or Metallurgy, for example. In the latter case it may merely be a matter of bringing all such courses together in one list.

The matter of giving graduate work in machine design has been a debatable question, particularly when the student has had strong undergraduate courses in the subject and when he has no particular project in mind. In such a case the graduate work is too likely to become merely the design of another machine involving few new principles, and it probably would be better for the student to select courses related to design from some other department. For example, unless the student is interested in a project on which the instructor believes he can spend his time profitably he might be advised to take an advanced course in the allied fields of mathematics, mechanics, strength of materials, or fluid dynamics.

A survey of the graduate work now offered in machine design indicates that the variation is due chiefly to the fact that each college or university has equipment and facilities that enable it to place emphasis on certain types of work. Otherwise this work can be listed under a comparatively small number of headings. In some instances the work consists of original projects of an

advanced nature, arranged as far as possible to meet the needs of the particular student. These projects may be in the fields of power plant machinery, hoisting and conveying equipment, machine tools, or automotive and airplane engines, and the problem may consist of the complete design in detail of some machine, vehicle, or plant for manufacturing or power production purposes, or an analysis or design in conjunction with experimental or research work. In some cases the graduate course is about the same as the advanced undergraduate course, with extra work and outside reading being required for graduate credit. This continuation of an undergraduate course, making it sufficiently advanced in character for graduate credit, seems to cover a number of cases. Running through the catalog material on graduate courses, however, indicates that graduate courses are classified, for the most part, as advanced machine design, Diesel or gasoline engine design and analysis, machine tool design, dynamics of machines, process machinery, laboratory investigations, critical speeds and vibrations.

The procedure that seems to prevail in a number of well recognized colleges and universities is that of giving regular graduate work in machine design to the student who has a definite design project in which he is vitally interested and in which the instructor believes the student's time can profitably be spent. Otherwise, the student is encouraged or advised to seek graduate work in the related fields in other departments in subjects such as higher mathematics, advanced mechanics, structural mechanics, theory of elasticity, property of materials, materials testing, metallurgy, hydraulics, aerodynamics, and methods of analysis.

Comments and discussion on any material appearing on this page are invited.—THE EDITOR.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

A. W. LEIGHTON, *Editor*, Tufts College

SELLING THE INTANGIBLES

Many authors are continually urging that in order to save the face of Descriptive Geometry, more and more of the practical applications of the subject be sold to the student. The writer has long felt that this way of justification is one-sided, too easy and popular, indicative of desperation on the part of drawing teachers, and often self-defeating.

Certainly we need to present frequent applications to give the proper amount of glamour to the subject, but more certainly do we need to *sell to the student* the more or less intangible benefits to be derived from its study. This is not easy to do. These objectives are well known to all drawing teachers, but it seems that few care to divulge these mysteries to their charges. The student is usually promptly informed of the useful applications of any theorem, but is more often left completely unaware of the so-called "non-practical" aspects of the problem. Not only should these intangible aims be clearly set forth in the introductory work, but they should also be continually and appropriately emphasized throughout the course as well as summarized at the end.

The following are a few of the possible selling points that could be used: (1) the development of the power of visualization, (2) a more satisfying appreciation of the engineer's graphic language, (3) practice in the application of fundamental knowledge to the solution of new and difficult situations. The first point is probably understood universally by both teacher and student as a major aim of Descriptive Geometry, but there exists ample opportunity during the course to re-emphasize it. Even the poorest student will concede that the second point is well taken. The third point might well be used to justify the special case type of problem which students are inclined to call "trick" problems, especially when given on tests. These will rightfully be resented as unfair unless they can be amply justified. The motive behind these problems is to get the student into the habit of unfalteringly applying his fundamental theorems to unusual and unexpected positions of the given elements. He should remember that his whole engineering course is devoted not so much to the task of training him specifically for every problem of his future career, as it is to teach him a few basic principles and developing in him enough analytic ability to apply them reasonably well to the new and unpredictable situations that may arise in his later work. The long problem involving many stages in its solution may also be sold as excellent training in developing accurate, sure-footed, concentrated persistence toward an end. Countless other possibilities along this line will suggest themselves automatically to instructors interested in this type of salesmanship.

In conclusion, only through a balanced and complete exposition of both the practical and intangible objectives of Descriptive Geometry will students —and incidentally administrators—be convinced of its worthiness of retention in the curriculum.

RALPH E. BROWN,
Associate Professor of Mechanical Engineering, Rhode Island State College

NECROLOGY

STANLEY SYLVESTER SEYFERT, head of the Department of Electrical Engineering at Lehigh University, died on December 11, 1939, as a result of a heart ailment. He was 58 years of age.

In point of service, Dr. Seyfert was one of the oldest members of the Lehigh faculty. He completed 35 years of teaching at Lehigh last June, having accepted a position as instructor in electrical engineering upon his graduation from the University with top honors in electrical engineering in 1904. In 1909 he received the degree of Master of Science from Lehigh and in 1932 Massachusetts Institute of Technology awarded him the doctorate.

Dr. Seyfert was widely known in his profession and held several patents on devices in the electrical field. He was the author of numerous papers and co-author of a laboratory manual and was active in engineering and other societies. At the time of his death he was chairman of the Lehigh Valley Section of the American Institute of Electrical Engineers.

He was a member of the American Institute of Electrical Engineers, the Institute of Radio Engineers, the Society for the Promotion of Engineering Education, Tau Beta Pi, Eta Kappa Nu and Sigma Xi.

GEORGE EARLE BEGGS was born at Ashland, Ill., on April 22, 1883, and died November 23, 1939. He graduated from Northwestern University with the degree of A.B. in 1905. After graduate work at Columbia University under Professor William Burr he received the C.E. degree in 1910. After several years with the American Bridge Company and with Phosphate Mining Company of Florida as chief engineer, he taught for one term at Union College and in 1914 he was called to Princeton University as instructor in civil engineering. He became an assistant professor in 1915, an associate professor in 1921 and professor in 1930. Upon the retirement of Professor Constant he became chairman of the Department of Civil Engineering in 1937.

RALPH EDWIN GOODWIN was born at East Hartford, Conn., September 26, 1886 and died December 16, 1939. He received his B.A. degree at Yale in 1908, and a year later obtained his Ph.B. degree. After graduation he was assistant instructor in surveying and student engineering at Yale. In 1912, Yale University

presented him with his professional C.E. degree. After a short period of instruction at Columbia and Yale, he became a surveyor on the N. Y. C. R. R., Assistant Engineer of the N. Y. Board of Engineers of the N. Y. Board of Water Supply, Junior Engineer in charge of the testing laboratory of the N. Y. State Public Service Commission, Engineering Estimator for the Chile Exploration Co., and Engineering Inspector of the U. S. Shipping Board.

He came to the College of the City of New York in November, 1922, as an estimator in the Veterans' Vocational Training School. He rose from Instructor to Associate Professor of Civil Engineering.

Frederick Newton Willson was born at Brooklyn, New York, on December 23, 1855, and died November 15, 1939. He entered the Class of 1878 of the Rensselaer Polytechnic Institute, withdrawing in his junior year to aid his father in the conduct of the Troy Academy. He completed his course with the next class, receiving his C.E. degree in 1879 and took postgraduate work in Psychology and Philosophy with his friend, Dr. Daniel S. Gregory, President of Lake Forest University, Illinois. In December, 1880, he became an instructor in descriptive geometry, stereotomy and drawing at Princeton University in the John C. Green School of Science, being called by President McCosh from a business career with Drexel-Morgan & Co. In 1883, he was advanced to the rank of professor, and in 1922 the Department of Graphics and Engineering Drawing was established and he became the first chairman before his retirement in 1923. Professor Willson was the author of one of the most advanced books on graphics which included discussion of the whole field of this subject. Not only did he cover the ordinary divisions of this subject, but he discussed their mathematical aspects. During his professorship, he built up most complete collections of models for teaching descriptive geometry, for illustrating warped surfaces, and for the teaching of mechanism. Few institutions have collections equal to those which were secured by him for Princeton University.

COLLEGE NOTES

University of Alaska.—Our five-year engineering courses are working well. Two or three of the best students each year prefer to complete the longer program, many of them taking both degrees, the bachelor of science, as well as the bachelor of civil engineering. It requires a total now, of 134 semester hours for the four-year degree, and a total of 170 for the five-year engineering degree.

The **American Association of Junior Colleges** has received a grant of $25,000 from the General Education Board, of New York City, to finance a series of exploratory studies in the general field of terminal education in the junior college. Approximately 500 accredited junior colleges are now found in the United States besides another hundred which are not yet thus recognized.

About two-thirds of the 175,000 students enrolled in these institutions do not continue their formal education after leaving the junior college. The new study will be concerned particularly with courses and curricula of a semi-professional and cultural character designed to give this increasing body of young people greater economic competence and civic responsibility. There is increasing evidence that existing four-year colleges and universities are not organized adequately to meet the needs of a large part of this significant group.

It is anticipated that the exploratory study will reveal the need and the opportunity for a series of additional studies and experimental investigations and demonstrations which may cover several years of continuous effort.

University of Cincinnati.—Continued increase in enrollment in the College of Engineering and Commerce, despite the adoption of more stringent entrance requirements, has been responsible for an overcrowded condition in the engineering buildings. To provide for an expansion of facilities, the construction of an addition to the present chemistry building was begun in the fall of 1938 and the new part opened for use at the resumption of classes in 1940 following the Christmas holidays. On Friday, January 26, 1940, the building was dedicated with appropriate ceremonies planned and presented by student organizations. Professor A. H. White, Professor of Chemical Engineering at the University of Michigan was the guest speaker on this occasion.

The new addition has been constructed in such a way as to form

one unit with the old building: a large square with a centrally located court above the first floor. The new part adds about 60,000 sq. ft. of floor space distributed over five floors and an attic to the old building which has about 50,000 sq. ft. over four floors and an attic. The entire building is now more than double its former size and becomes one of the largest on the campus. There is now sufficient lecture room space in the building to provide for approximately 1,500 pupils at one time.

The plans for the building were under the supervision of R. S. Tour, Professor of Chemical Engineering and head of that department, and H. J. Garber, Instructor in Chemical Engineering.

New faculty members in Chemical Engineering are John F. Kahles, Instructor in Metallurgy, and Wm. Licht, Jr., Instructor in Chemical Engineering. Mr. Kahles holds a B.Sc. degree from Armour Institute of Technology and was graduate assistant in Chemical Engineering at Cincinnati prior to his appointment. Mr. Licht holds Ch.E. and M.S. degrees from Cincinnati.

The Cooper Union.—During the past year, a complete revision of the civil engineering curriculum was effected under the direction of Associate Professor Ray C. Brumfield and made effective with the beginning of the current school year. Among the more important changes was the addition of courses in Photogrammetry, Soil Mechanics and City Planning. During the summer, equipment for a Soil Mechanics Laboratory was installed, including a constant temperature and humidity room. A summer surveying camp period was inaugurated, day students attending the University of Maine camp, and night students spending a two-weeks' session at the New York University camp. Due to the generosity of Norvin Hewitt Green, a great-grandson of Peter Cooper, Cooper Union will have its own camp next summer, a gift having been accepted of 150 acres in New Jersey on the Ringwood estate of the late Abram S. Hewitt, son-in-law of the Founder, and Secretary of the institution from 1859 to 1903. Among the changes to the staff of the Civil Engineering Department are Professor Edward S. Sheiry, former Head of the Civil Engineering Department at Robert College, Istanbul, as Professor of Civil Engineering and Head of the Department; Ralph Eberlin, B.S. Cooper Union '15, prominent authority on City Planning, as Lecturer and Consultant in the City Planning Course; Eivind Ramberg, B.C.E. Polytechnic '37; Claude M. Roberts, A.B. Hiram College, Sc.M. N. Y. U.; William J. O'Donnell, B.S. Cooper Union '32, M.C.E. Cornell '33, Ph.D. Catholic University of America '37, as instructors; the promotion of Assistant Professor Ray C. Brumfield to the Associate Professor grade; and the promotion of Charles O. Roth to the rank of Assistant Professor.

In the Department of Electrical Engineering, laboratory facilities have been extended by the installation of a new rotary converter and polyphase mercury arc rectifier equipment, as well as by a number of new machine assemblies for laboratory work in unbalanced circuit theory. New storage batteries, oscillographs, instruments, and auxiliary apparatus supplement these newly installed facilities. In order to assist in the development of the work of the Department in the field of high frequency communication, application and measurement, there has been engaged for full-time duties, Jesse B. Sherman, B.S. Cooper Union '33, B.S. N. Y. U. '35, M.E.E. Polytechnic '38. Mr. Sherman is the author of several professional papers and, for the past five years, was connected with the RCA Manufacturing Company in high frequency developments.

In the Department of Mechanical Engineering, Walter S. Kut, M. I. T. '34, has been devoting full-time duties to the development of the Automotive Laboratory. In this connection there were acquired, during the summer, a Chevrolet engine unit and General Electric hydraulic dynamometer, a CFR variable compression engine with additional Diesel head, and a 60 cfm Chicago portable air compressor with gasoline engine drive. William A. Vopat, B.S. Cooper Union '31, M.S.E. Michigan '37, M.E. Cooper Union '39, has published in photo offset form a syllabus of his lectures on Power Plants and has assembled a very striking exhibit of the various grades of solid fuels which has been supplemented by a gift of anthracite sizes. Additions to the staff include Arthur F. Tuthill, Carnegie '38, Wisconsin '39, as full-time instructor and George Mackas, M.E. Cornell '24, of the Motive Power Department of the Interborough Rapid Transit Company, as part-time instructor.

During the past year and summer, rapid strides have been made in the equipment of the new Chemical Engineering Laboratory located on the ground floor and basement of the Foundation Building. In addition, extensive changes have been made to the chemical laboratories through better space utilization. New offices have been provided and stock room and storeroom facilities relocated and enlarged, and enough space freed for the installation of a research laboratory. Among the changes to the staff are the appointments of Franklin M. Spooner, S.B. M. I. T. '39, as full-time instructor; Harry G. Taylor, B.Ch.E. Cooper Union '39, as Teaching Assistant; Evan Thomas, University College, Cardiff, England, M.S. N. Y. U. '39, metallurgist with the Bell Telephone Laboratories, as evening instructor in Metallurgy; Albert J. Monack, West Virginia University, as evening instructor in Chem-

istry; and the promotion of Dr. Henry B. Hope and Raymond J. F. Kunz to the rank of Assistant Professor.

In the Department of Physics, the personnel has suffered by the loss of Professor Karl Hauptman, B.S. Cooper Union '03, who passed away in the fall after 34 years of faithful and devoted service. Fred C. Vonder Lage, B.S. University of California '33, has been appointed as instructor.

In the Department of Mathematics, the following additions to the evening staff have been made: Willard E. Bleick, M.E. Stevens '29, Ph.D. Johns Hopkins '33; and Samuel E. Sklar, C.E. Polytechnic '35, M.S. N. Y. U. '37.

In the Department of Machine Design, a new drawing-room has been added and specially designed drafting tables provided. During the past year, members of the Department have constructed a small portable reflecting type polariscope, as well as a large scale model of a Geneva Stop mechanism. Additions to the staff include Robert P. Muhlsteff, B.S. Cooper Union '31, B.S. N. Y. U. '36, of the Bell Telephone Laboratories; and Charles D. Hanley, B.S. M. I. T. '35, of Cox and Gibbs, as part-time instructors.

By the establishment of a Department of Humanities, the work of the various non-technical courses has become more effectively coördinated, and by the provision of an adequate staff it has been possible to almost double the time previously devoted to non-technical subjects in the day courses. The following new subjects have been added: History of Western Civilization, American Literature, American Government, and Public Speaking. The Colloquia in Social Philosophy, inaugurated last year, have proved eminently successful and so are continued during the current year. To head the newly formed Department, there has been appointed William S. Lynch, Holy Cross '25, A.M. Harvard '35, formerly of the Rindge Technical School, Cambridge, Mass. Other appointments to the staff are Ralph de S. Childs, A.B. Harvard '24, and Richard S. Bowman, B.S. Haverford College '38, both as full-time instructors.

The **University of Iowa** is offering a special three-week course for people in industry interested in comprehensive training in motion and time study, waste elimination, cost reduction, and related subjects, June 10 to 28, 1940. The course, offered for the first time last year, was attended by executives and engineers from 25 different industries in the United States and Canada. The Summer Management Course will be under the direction of Ralph M. Barnes. Assisting in the course will be seven University instructors and lecturers and eight visiting managers and engineers from industry who will conduct forums on practical production problems.

THE TEACHING STAFF AND UNIVERSITY LECTURERS:

Ralph M. Barnes, Director of Summer Management Course, and Professor of Industrial Engineering, College of Engineering, University of Iowa.

L. P. Persing, Supervisor of Wage Payment, Fort Wayne Works of the General Electric Company.

J. V. Balch, Research Engineer and Instructor in Industrial Engineering, College of Engineering, University of Iowa.

Robert E. Box, Engineer in Charge of Industrial Engineering Laboratory Equipment, University of Iowa.

Lester Thonssen, Professor of Speech, College of the City of New York, New York.

W. L. Daykin, Assistant Professor of Economics, College of Commerce, University of Iowa. (Lecture on Labor's Attitude Toward Cost Reduction Work.)

Dewey Stuit, Associate Professor of Psychology, College of Liberal Arts, University of Iowa. (Lecture on The Use of Tests in Employment Procedures.)

C. M. Updegraff, Professor of Law, College of Law, University of Iowa; Formerly Associate General Counsel for the National Association of Manufacturers and Editor of the N. A. M. Law Digest. (Lecture on The Federal Government and Labor Law.)

A. C. Baird, Professor of Speech, College of Liberal Arts, University of Iowa.

VISITING LECTURERS AND FORUM LEADERS:

John A. Aldridge, Executive Operating Staff, Sears, Roebuck and Company, Chicago, Illinois. (Lecture on Motion Study in the Field of Distribution.)

L. A. Bradley, Manager, University of Iowa Laundry, Iowa City, Iowa. (Lecture on Motion Study Applications in the Commercial Laundry.)

W. E. Crotsley, Production Manager, International Business Machines Corporation, Endicott, New York. (Lecture on Methods of Production Control.)

Erick G. Erickson, Chief Engineer, Buddy "L" Co., East Moline, Illinois. (Lecture on Cost Reduction Through Better Design of Product, More Effective Utilization of Materials, and Improved Manufacturing Methods.)

Lillian M. Gilbreth, President, Gilbreth Incorporated, Montclair, New Jersey, and Professor of Management, Purdue University. (Lecture on Motion Study and the Democratic Process.)

W. F. Heising, Superintendent of Manufacturing, W. A. Sheaffer Pen Company, Fort Madison, Iowa. (Lecture on Stabilization of Employment.)

J. K. Louden, Supervisor of Standards Control Division, Owens-Illinois Glass Company, Toledo, Ohio. (Lecture on The Application of a Wage Incentive System.)

The University of Iowa is well known for its instruction in industrial engineering, and the results of research in this field carried on in its laboratories are receiving wide attention by manufacturers. The three-week course is arranged for people from industry who want to obtain practical training in cost reduction methods.

University of Louisville.—Additions to the faculty of the Speed Scientific School in September included the following:

Carl Adams, B.S.E. and M.S., University of Michigan, instructor in physics. Mr. Adams was formerly student assistant at the University of Michigan.

William S. Bowmer, A.B., Amherst College, instructor in English. Mr. Bowmer formerly taught at the du Pont Manual Training High School, Louisville, and in the Division of Adult Education, University of Louisville.

Carl Loewner, Ph.D., German University, Prague, instructor in mathematics. Dr. Loewner was formerly a member of the faculty of German University, Prague.

John A. Straw, B.S., Rose Polytechnic Institute; M.A., Michigan State College, instructor in mathematics. Mr. Straw has been a part-time instructor at Michigan State College and Brown University.

The total registration in engineering includes 305 students, distributed as follows: 254 in the regular day division of the Speed Scientific School, 33 registered in the freshman engineering curriculum of the Division of Adult Education, and 18 engineering students registered in the Graduate School.

SECTIONS AND BRANCHES

During the year 1939, the **University of Detroit Branch** of the Society held regular monthly meetings in conjunction with the faculty of the Engineering Department, the meetings being held under the auspices of the S. P. E. E. Meetings were scheduled for the third Thursday of each month that school was in session.

The practice of having the officers of the S. P. E. E. preside at these meetings was continued. The officers for the year 1939 were as follows: Clair C. Johnston, Professor of Civil Engineering, Chairman; Ralph W. Tapy, Assistant Professor of Electrical Engineering, Vice Chairman; and Clayton J. Pajot, Assistant Professor of Engineering Mechanics, Secretary.

Throughout the year, talks were given by various members of the engineering faculty relating to their particular branches of engineering or engineering education so that members of the different departments might become better acquainted with the progress, and objectives of other departments, and so that each one might be able to form a better estimate as to how his work fitted in with the educational scheme as a whole. The purpose was also, of course, to enable the members of the faculty to profit by the experience and knowledge of members of other departments. The talks were given after the business of the meetings had been completed. Discussion by the various members of the faculty followed each talk. In some cases the talk together with the discussion required more than one meeting.

The first talk was given by Herman E. Mayrose, Professor of Engineering Mechanics. Professor Mayrose discussed an address given by William John Macquorn Rankine on the "Harmony of Theory and Practice in Mechanics" originally delivered before the Senate of the University of Glascow on Dec. 10, 1855. He also discussed briefly the methods and objectives of the Engineering Mechanics Department.

The next talk was given by William P. Godfrey, Assistant Professor of English and Head of the Department of Engineering English. Professor Godfrey discussed the objectives and curricula of the Engineering English Department. He summarized the objectives as follows:

To teach the student

(1) to think clearly
(2) to express himself clearly, both orally and in writing

(3) to read intelligently
(4) to develop standards of taste.

A very interesting talk was also given by Professor L. S. Johnston, in charge of the department of Engineering Mathematics, regarding the development of the number system. Professor Johnston also discussed the mathematical periodicals explaining their use in connection with applied science such as Engineering.

At the March meeting, the chapter was very fortunate in obtaining as guest speakers, Mr. Fulkrad and Dr. J. O. Perraine, both of the Michigan Bell Telephone Company. Mr. Fulkrad introduced Dr. Perraine, who then gave a very clear and enlightening discussion regarding the advancement in communication during the last twenty years.

Election of officers was held at the last meeting of the year, namely that of December 19, 1939, when officers for the year 1940 were selected. The officers chosen were as follows: Peter Altman, Professor of Aeronautical Engineering, Chairman; C. G. Duncomb, Professor of Chemical Engineering, Vice Chairman; William P. Godfrey, Assistant Professor of English, Secretary.

The twenty-fourth annual meeting of the **Kansas-Nebraska Section** of S. P. E. E. was held at the University of Kansas on October 20 and 21, 1939. The afternoon of October 20, Friday, was devoted to registration and the pleasantries of informal visits among the visitors and hosts. The annual Friday evening dinner was served in the Kansas Room of the Memorial Union Building. An overflow assembly (143 in all) was present. A quartet of K. U. engineering students, with accompanist, provided much appreciated entertainment.

Following the dinner Professor C. E. Pearce (K. S. C.), as presiding officer, called the assembled group to order. Guests from the University of Omaha, Missouri School of Mines, Kansas State Teachers College at Pittsburg and Fort Hays were introduced.

A nominating committee consisting of V. P. Hessler (K. U.), F. W. Norris (N. U.), and L. Helander (K. S. C.) as Chairman, was appointed.

President Pearce requested the chairman of each round table group to appoint a secretary and be prepared to submit, during the business meeting, brief reports on their round table programs.

Dean O. J. Ferguson (N. U.), President of the Society for the Promotion of Engineering Education, was introduced with generous applause. He confined his talk to the topic "Fundamental Fundamentals." His preliminary remarks directed attention to the breadth of content of the papers in the publications of S. P.

E. E. Sample titles of papers were quoted and the contrasts in the titles were stressed. They served to indicate the breadth of research and study that has been directed to problems of engineering education. President Ferguson emphasized the basic fundamental of getting at the core of the problem of effective teaching. He stated that it is important to encourage ourselves to attack the core, and that nothing is more important than the personal relation between student and student and between the teacher and students. The relationship of person to person is a vitalizing influence and provides an opportunity to teachers for the development of the latent possibilities of students. Thus we may teach even more than we know. When fully developed the relationship of person to person should come near to being the creation of an individual.

Following the talk by Dean Ferguson, President Pearce introduced Deane W. Malott, Chancellor of the University of Kansas, as speaker of the evening. Chancellor Malott extended a cordial welcome to all guests and expressed his real interest in the activities of the Kansas-Nebraska Section of S. P. E. E.

Chancellor Malott's address, "A Glimpse Towards The Future," lead up to the point of view that engineering education should stress the broader aspects of education, that it should provide training for administration and human leadership as well as for leaders of technical science. The various industrial revolutions during the past century and their effects on social and economic organizations were outlined briefly. The disturbances due to periods of marked social disintegration and concentration of population in cities have been accompanied by an increasing measure of confusion in our social and economic world. Out of the frontier of the many movements engendered by an ever growing technology the management phase has emerged. The pressure for raw materials to supply the special demands of mankind has emphasized the importance of administration in our modern industrial organization, but unfortunately the human elements in industry have received scant attention. The effects of "sentiments" in the lives of employees demand a broader outlook in problems of human leadership in the present age. Engineering education should have a focal point to the end that we may develop leaders of thought and of men, as well as leaders of the technical sciences.

At the conclusion of Chancellor Malott's address the dinner meeting was adjourned. The ladies retired for an evening of entertainment in charge of Mrs. G. W. Bradshaw. The several Departmental Round Table Meetings convened at their respective meeting places, each holding forth until a late hour.

Prior to the business meeting on the following Saturday morning, many of the visitors availed themselves of the opportunity

afforded to inspect the engineering laboratories and other university buildings of special interest.

The general business meeting of the Section was called to order at 10:20 A.M., Saturday, with President Pearce presiding. Brief oral reports were called for from the chairman or secretary of each departmental round table group. These reports reflected much interest and value gained in the departmental discussions. The topics discussed and the new chairman for each round table group are given under the following headings:

Applied Mechanics: Chairman, F. L. Brown (K. U.).

E. R. Dawley (K. S. C.) reported on the sessions of the Applied Mechanics Division of S. P. E. E. at the Penn. State Annual Meeting.

W. L. DeBaufre (N. U.) led an interesting and instructive discussion on "Methods of Teaching Strength of Materials."

G. Pickett (K. S. C.) was elected chairman for the 1940 meeting.

Architecture: Chairman, J. M. Kellogg (K. U.).

The meeting was quite informal and included an inspection of student design problems and new drafting room tables and lighting equipment.

P. Weigel (K. S. C.) will serve as chairman for 1940.

Chemical Engineering: Chairman, W. W. Deschner (K. U.).

T. H. Marshall (K. U.) presented a paper on the "Undergraduate Curriculum in Chemical Engineering." Data for 31 accredited institutions were presented and a number of curriculums in chemical engineering were compared.

W. L. Faith (K. S. C.) presented a paper on the "Graduate Program in Chemical Engineering." His paper raised several important questions for study.

J. E. Hedrick (K. S. C.) was appointed to serve as chairman for 1940.

Civil Engineering: Chairman, R. F. Morse (K. S. C.).

S. White (K. S. C.) presented excerpts of opinions of Kansas State College faculty members on administrative and teaching work at that institution. Frank opinions had been requested by President Farrell of K. S. C. Professor White quoted selected criticisms and recommendations, and a rather interesting discussion resulted.

D. H. Harkness (N. U.) was elected chairman for 1940.

Electrical Engineering: Chairman, V. P. Hessler (K. U.).

The round table discussions centered on the objectives of electrical engineering laboratory work.

R. M. Kerchner (K. S. C.) was elected chairman for 1940.

Engineering Drawing: Chairman, J. W. Kurtz (Omaha U.).

A report on the S. P. E. E. meetings on engineering drawing at Penn. State was presented by E. J. Marmo (N. U.). A discussion of the question of a correlation between solid geometry and drawing grades was led by F. A. Smutz (K. S. C.)

E. O. Morton (N. U.) was elected chairman for 1940.

Engineering English: Chairman, F. N. Raymond (K. U.).

A general statement was made of the work of the S. P. E. E.'s special Committee on English and the study recently made by Doctor Fountain of North Carolina. Discussions centered about the need of making clear to students the importance of their English training, experiences in teaching technical report writing, and tutorial advice for students after they are beyond their required English courses.

E. H. Peterson (K. S. C.) was appointed chairman for 1940.

Mathematics: Chairman, W. C. Brenke (N. U.).

The mathematics group had two successful meetings. One was held on Friday evening and the other on Saturday morning. The programs of both of these meetings were particularly good and well attended.

H. E. Jordan (K. U.) was elected chairman for 1940.

Mechanical Engineering: Chairman, J. A. King (K. U.).

E. D. Hay (K. U.) led an interesting discussion on the "Civil Aeronautics Pilot Training Program." He reported on a meeting at Washington during the summer which was attended by representatives of 13 institutions having this program. The objectives of this training were outlined, and the training methods being used at K. U. and other institutions were discussed. J. A. Shirk (K. S. T. C.-Pitt.) reported on the progress made in the training program at K. S. T. C. There followed a general discussion of methods and regulations used at various institutions and of what might be expected of the future.

L. Helander (K. S. C.) was elected chairman for 1940.

Following the reports on the round table meetings, President Pearce brought up the question as to whether it was desirable to include the various round table reports in the Saturday morning session. No preferences were expressed.

The Nominating Committee presented the following report which was unanimously adopted:

For President: W. C. Brenke, University of Nebraska.

For Secretary: G. W. Bradshaw, University of Kansas.

Program Committee: F. F. Frazier, *Chairman,* Kansas State College; W. F. Weiland, Univ. of Nebraska; A. M. Ockerblad, Univ. of Kansas.

The invitation of Professor L. Helander to meet at Kansas State College in 1940 was accepted.

Following the business session E. A. Stephenson, Chairman of the Department of Petroleum Engineering, University of Kansas, presented an interesting and instructive illustrated lecture on "The Field of Petroleum Engineering."

The Saturday morning program was adjourned at 12:30 P.M.

A fine noon luncheon was served in the Kansas Room of the Memorial Union Building. Professor Pearce, as retiring President, tendered the K. U. hosts the thanks of all the visitors for the courtesies arranged by the local committees and for another enjoyable and successful section meeting. All retiring and newly elected officers of the Section were introduced. The 24th Annual Meeting of the Section was adjourned at 1:35 P.M.

M. I. EVINGER,
Secretary, 1939–1940

The Lafayette College Branch has held four meetings on the following subjects: (1) "Effect of Adequate Pre-College Training upon Success in College," (2) "The Boys' Engineering Guidance Conference," (3) "Methods to Improve Upperclassmen's Application of Underclass Training," and (4) "Admitting Freshmen to Advanced Standing by Examinations." While stimulating discussion clarified all these questions, of primary interest were the discussion of plans for the seventh Boys' Engineering Guidance Conference at Lafayette College and receiving an evaluation of the previous conferences. We now have complete records of approximately two hundred boys who have attended the previous conferences. We feel that it is such a fine idea it should be more universally used and perhaps administered on a regional basis by some organization as the Engineers' Council for Professional Development.

W. G. MCLEAN,
Secretary

North Carolina State College.—Programs of the local unit of the S. P. E. E. this year have been unusually successful and well attended. They have carried forward a practice begun last year, a practice whereby at least a part of the programs are devoted to discussion and coördinating of the separate departments touching the same students. For example, this year has brought a discussion of mathematics as it is taught to upperclass engineers, as well

as a program in which was discussed the curriculum in agricultural engineering. Other topics discussed have had to do with the general problems of teaching, under such titles as "What Are Our Functions as Teachers?" and "Improvement of Engineering Teachers through Professional Practice and Research."

Also carrying out a rule begun last year, the last meeting will be a dinner session, at which will be reviewed the work of the year. An address by an outstanding citizen will bring the banquet and the year to a close.

Since the membership of the S. P. E. E. and the engineering faculty personnel are almost identical, a close correlation between the programs of the two groups is possible. In addition to the discussions of the problems of teaching, the faculty group has emphasized discussions of summer travels and research, and their instructional value.

The engineering school during January, in conjunction with several other agencies, brought to the campus outstanding lecturers, and participated in other activities incident to the observance of "engineers' week." First was a two-day safety school for truck drivers, put on by the extension division of the college and led by Professor Harry Tucker, authority on highway safety. Next to the college was host to the annual meeting of the North Carolina Society of Surveyors.

Immediately following the meeting of surveyors came the annual Engineers' Institute. Discussion this year centered on the problems of transportation. Lectures and discussions were made by members of the faculty, and by such outside authorities as: Leslie C. Allman, Vice-President, Fruehauf Trailer Company; Brig.-Gen. Thomas M. Robins, Asst. Chief Engineer, U. S. Army; Oswald Ryan, C.A.A.; J. E. Teal, Transportation Engineer, C. & O. Railway; Roy V. Wright, Editor of *Railway Age*.

Dr. Wright's lectures, a series of them, were a part of the public lectures program of the year, as well as a part of the Engineers' Institute.

During "engineers' week," the college suffered an irreparable loss in the sudden death of Professor W. G. Geile, head of the department of structural engineering. Professor Geile had not only been instrumental in building up the department he headed, but had also integrated and published the North Carolina Building Code, and had been instrumental in starting a student chapter of Associated General Contractors.

BOOK REVIEWS

Engineering Physical Metallurgy. ROBERT H. HEYER. D. Van Nostrand & Co., New York. 1939. 549 pages. 6 × 9 inches, price $4.50.

The author's preface states that he has tried to present in a simple way adapted to "the instruction of non-metallurgical students" a condensed, correlated and up to date treatment of "the various materials, methods, and concepts of metals technology." In doing so he has produced an excellent text, both for the above purpose, and as a reference book for many salesmen, engineers, and executives in the metal-using industries.

The book appeals to the present reviewer as something of an intermediate type between a handbook for the practising engineer, a reference book for the skilled metallurgist, to bring him up to date in a general way on lines outside of his specialty, and a text book for the beginning non-metallurgical engineering student or even, possibly, for the starting metallurgy student. For this last use, however, my preference might be rather for a text of a different type—one with a very strong emphasis on basic principles, even though presenting a much more limited list of subjects.

It is evident that the text was very carefully written. The arrangement of material is good, and the English is clear and to the point. Moreover, the printing, choice of paper, and the illustrations leave little to be desired.

Bearing in mind that the text is a presentation of the physical metallurgy—or structures, treatments, and properties of metals and alloys—and written from a metallurgical viewpoint, rather than emphasizing processes, equipment or production, a list of headings, and number of pages in each, of the fifteen chapters will indicate very well the wide range of subjects that is included, and something of the emphasis on each: Pure Metals, 21; Principles of Alloying, 22; The White Metals and their Bearing Alloys, 14; Light Alloys, 34; Die Castings, 9; Copper and its Alloys, 52; Iron and Carbon Steels, 49; Heat Treatment of Steel, 61; Low and Medium Alloy Steels, 51; Surface Treatment of Steel, 43; Steel Castings, 30; Welding, 26; Cast Iron, 53; High Alloy Steels, 46; Tool Steels, 23; Appendix and Index.

S. L. GOODALE